Establishment of an agribusiness model for assessing the commercial viability of new species for aquaculture.

Volume Two

David Douglas Otton M Bus (Agribus)

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School of Aquaculture, University of Tasmania at Launceston

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CHAPTER SIX

APPLICATION OF SELECTION CRITERIA TO ASSESSMENT SPECIES

Quad erat demonstrandum

(Which was the thing to be proved)

6.1 Introduction

The thinking prior to and during the present work was to apply the concept of agribusiness to the science of aquaculture with a new product development template adapted from mainstream industry. In motion, the work needed to develop an intellectual thread that considered a new species as a new product. A new species must meet certain performance criteria to be successful, posing the question; does this work if new species are viewed as new products? The work needed to establish success criteria and the results provided data conveniently represented as concentric circles with *must haves* at the core, then *should haves,* followed by the *could haves* on the outside. Some success criteria though present lacked strength in some species, for example closed lifecycle in striped trumpeter and posed a further question on the ability of current and evolving technology to manage and overcome these problems.

A process of pattern matching, explanation building and developing new theory emanated from Chapter 4 Results and Chapter 5 Discussion. Taking into consideration the results and work of Le François (2002) and Quéméner (2002) it is obvious that assessment of a new species cannot proceed until the data base has reached a certain level. The developer must therefore weigh up the financial risks involved in completing the desired data base if one does not or only partially exists. The results of the present study indicated that one species could piggy back through development and even into the market on another species. For example, lemon sole piggy-backed on Atlantic halibut in Great Britain and Atlantic cod piggy-backed on Atlantic salmon in the Northern Hemisphere. Should a company venture forth and develop a new species it should retain ownership of the technology to offset the cost of development. Though not immediately obvious, in domesticating and farming a new species there are some events in its lifecycle which are likely to be critically important, others sequentially important, and some areas where aquaculturalists have no control. If a performance template cannot be constructed and the developer cannot see ahead, the firm has to ask itself: how does it proceed, if at all? Also, the modelling process may indicate what is contributing to errors in the new species development process.

6.2 Modelling

This chapter compares a suite of assessment species with a master model derived from the survey results. The benchmark or metric species (catfish, Atlantic salmon, barramundi) were chosen for the present study because of their differences (freshwater, marine, euryhaline), their success and the availability of data. None appear to have individual characteristics which differentiate their success from the others and, as aquacultured fish; all were either genuinely unique or perceived as unique products. Of the benchmarks, catfish is the only industry with an acknowledged model for development, but according to Shell (1993), it fails to show how to design a development project then implement it, and also fails to show how this process might be deliberately set in motion again for a different species.

The top ranking success criteria amongst the benchmarks were; being well known with market appeal, adaptable to farming, having technology available, good flesh recovery and multiple uses for the fish's carcass which generates a variety of different products to split into many different markets. Success criteria amongst the benchmarks decreased in commonality and diverged as the criteria lessened in order of frequency, indicating areas of individuality in each species which are not important in their overall assessment. The strategies for development were not generic amongst the benchmarks, and to adopt the same development strategy used for them, the assets must be available for the new product development process to commence. Weston *et al.,* (2001) noted the lack of data and information on new species and therefore the need to make various assumptions on costs of production and returns. An inherent danger in farming new species is the additional risk in using relatively new technologies and production techniques and the maturity of markets which sell the finished product (Weston *et al.*, 2001).

"There have been many aquaculture developments in Australia and in other parts of the world which have attempted to develop directly to perceived maximum commercial production with disastrous results. This approach fails to incorporate consideration of a large number of production variables, which in the planning of a development cannot be reliably quantified. It is frequently argued that these variables can be predicted through the consideration of similar operations. However, most if not all of the production variables associated with aquaculture are influenced by the characteristics of the production site. Indeed, production variables are usually influenced by spatial and temporal changes. Thus a staged approach provides the opportunity to quantify the production variables prior to full-scale development. This approach reduces the risk associated with environmental degradation and economic failure should the development prove to be unviable. (It also) provides the opportunity to 'fine tune' the infrastructure facilities and management approach in order to maximise the benefits of the first and subsequent development stages." (White *et al.*, 1996)

Modelling starts at the end of the value chain, the product/customer interface which is the product's final destination. The task is to research what the consumer wants, whilst analysing the firm's ability to satisfy that need. Where data reporting back through the marketing channel, meets data reporting forward through the production channel, is a defining go/kill decision point for new product development. The extrapolated screening and development criteria form a model for success in new species development taking a general case scenario from the catfish, salmon, and barramundi industries. Modelling establishes variables and applies economic validity against regulatory framework and risk assessment. Some variables are subjective judgements and others objective judgements.

The selection of Atlantic salmon *(Salmo salar)* as a benchmark species for the present study is externally validated by the inclusion of Atlantic salmon in Le François *et al's* (2002) and Quéméner *et al's* (2002) lists of successful species. This assists in underwriting the model's accuracy when applied to the benchmark species (established outcomes) before its subsequent application to the assessment species for predicting likely outcomes. In the analysis and appraisal process, the model must assess how the new species performs in the event by exploring specific outcomes and generating a range of scenarios in the aquaculture value chain. Should the model prove successful, it has general application to new (species) candidates for aquaculture development.

6.3 Assessment species

The species listed in Table 6.1 were identified by the present study as being of interest to industry in Australia and abroad.

Table 6.1 Species considered for investigation by the benchmark industries

Catfish industry	**Reason for investigation**
NWAC 103	A channel catfish bred by genetic selection which is said to eat 10% more feed and grow 10% faster.
Grass carp	Introduced to clean rooted vegetation in catfish ponds, therefore grown in polyculture. Growers found a market in the North American Asian community.
Freshwater clams	Species unknown. Introduced to clean pond water. Popular food of North American Indians
Hybrid Rocky Mountain white, grey& pearl tilapia	Species unknown. Selectively bred tilapia to retain the fish's "bullet" shape but make the flesh look even whiter
Salmon industry	**Reason for investigation**
Yellowtail kingfish	The site, infrastructure and resources are available to experiment with this species. Has a good recovery rate. Looking for a white species to complement the red species
Snapper	The site, infrastructure and resources are available to experiment with this species Looking for a white species to complement the red species Snapper occur naturally in the site area
Black bream	The site, infrastructure and resources are available to experiment with this species. Looking for a white species to complement the red species
Greenback flounder	The site, infrastructure and resources are available to experiment with this species. Looking for a white species to complement the red species
Striped trumpeter	Viewed as a species almost unique to south eastern Australian waters and is regarded as one Australia could grow better than any other nation and have a monopoly niche market. It has production and processing synergies with salmon and is suitable for the sashimi market. Looking for a white species to complement the red species
Barramundi industry	**Reason for investigation**
Atlantic cod	Popular white fleshed Northern Hemisphere fish. Substantial market, "fishery wrecked" and has same technology, site requirements as salmon
Cobia	Grows well (and quickly) in warmer climates Cages well and has a large market. Has a good recovery rate.
Milk fish	Euryhaline. Cleans vegetation in barramundi ponds and possibly useful for the same role in prawn ponds. Has a market in the Asian community.
Queensland grouper *(Epinephelus spp.)*	Gold spot cod and Queensland groper (grouper) are probably estuary rock cod *(Epinephelus coioides* Hamilton 1822) also known as orange-spotted cod but sometimes confused with other large spotted rock cods and the gigantic Queensland groper *(Epinephelus lanceoaltus).*
Gold spot cod *(Epinephelus spp.)*	

Barramundi industry	Reason for investigation
Golden snapper	May have future potential. Has production synergies with barramundi
Southern bluefin tuna	Has a huge market. Lifecycle is yet to be closed. Currently under going trials with pelletised feed rather than fish feed.
Barramundi cod	Lifecycle closed in Asia. Big current and potential market. Needs very good quality water.
Mangrove jack	Cost of production similar to barramundi. Second most requested fish requested for re stocking after barramundi. Euryhaline opportunity fish.
Mangrove cockle	Filters and cleans water in barramundi ponds Also known as Akul and mud mussel.
Big eye trevally	Opportunity fish. Euryhaline
Jade perch	Only a possibility. Also (more correctly) known as Barcoo grunter. Can tolerate water temperatures up to 40°C (Allen *et al.,* (2002)
Silver perch	Only a possibility

All benchmark industries are looking for alternate species that 'fit' with current operations. The thrust of the present study is to apply the model or assessment tool to a suite of species and predict the species success. Inability to apply the tool will indicate that the database is inadequate and will demonstrate what needs doing next to make a measured decision possible.

Within the terms of the present study it is not possible to assess all the identified species so the field was narrowed by removing those not native or endemic to Australia which included Atlantic cod, a looming future species. According to the survey results here, cod has the same technology as salmon and can use most existing salmon sites. Le François *et al.,* (2002) rated Atlantic cod number two in their assessment of species most likely to succeed in their strategy of growout and Quéméner *et al.,* (2002) rated Atlantic cod number one in their selected candidates for aquaculture on the French Atlantic, (English) Channel and North Sea coasts. The success of Atlantic cod suggests the work of Le François *et al.,* (2002) and Quéméner *et al.,* (2002) could be used to triangulate with the present study.

Species without fins were the second group struck out, eliminating mangrove cockles and crustacea (rock lobster, redclaw). From the remaining list some of those species identified in the present study as having been poorly screened were struck out. These were silver perch, golden snapper, mangrove jack, barramundi cod, coral trout mulloway, mullets, jade perch (Barcoo grunter), Murray cod, sleepy cod. Still on the list of those poorly screened were striped trumpeter, flatfish (flounders and halibut), yellowtail kingfish and snapper. At this stage species which had not been screened out were the above and black bream, cobia, milkfish, Queensland grouper, gold spot cod, southern blue fin tuna and big eye trevally. Of these, culture of southern bluefin tuna is well underway; cobia is produced aplenty in nearby Asia; sites are thought too limited for grouper and gold spot cod in Queensland, and milkfish is a secondary "pond cleaner" fish with a restricted market. This left species which have or are receiving formal research support. They are yellowtail kingfish, snapper, black bream, greenback flounder and striped trumpeter. King George whiting, though not identified in the survey is a species which continues to attract attention and has received support from the Australian FRDC and the Farmed Seafood Initiative of the South Australian (SA) Government. Black bream and greenback flounder lack some information, leaving snapper, yellowtail kingfish, striped trumpeter and King George whiting as the final suite of species. These species cover a broad range of Australian conditions and each species is at a different position along the path to commercialisation. All are white fleshed marine finfish for human consumption and native, but not endemic to Australia. Bream and flounder are included in Table 6.2 for interest only.

Table 6.2 Assessment species

Species	Stage of development	Research support	Suggested reasons for selection
King George whiting	Stage 1 Potential species	FRDC SA Farmed Seafood Initiative	Very popular fish with strong market appeal
Striped trumpeter	Stage 2 Trial Species	FRDC Aquafin CRC	Production technology is achievable. Species almost unique to south eastern Australian waters and is regarded as one Australia could grow better than any other nation and have a monopoly niche market. It has production and processing and marketing synergies with salmon. Suitable for the sashimi market. Looking for a white species to complement the red species
Black bream	Stage 2 Trial species	FRDC	Public interest
Greenback flounder	Stage 2 Trial species	FRDC Not current	Wide temperature and salinity tolerance. Biologically manageable. Unknown market potential. Secure technology. May be more manageable than striped trumpeter
Yellowtail kingfish	Stage 3 New species	Yes	Shows production figures and has operational and financial data available.
Snapper	Stage 3 New species	NSW Fisheries SARDI FRDC CRC	Shows production figures Pisces now publicly listed Redress wild catch shortfall Import replacement Likelihood of success

6.4 The Model

For the purpose of modelling, Table 5.11 Amalgamated Selection Criteria from Chapter Five Discussion becomes Table 6.4 'Master Model,' and is initially tested against the benchmark species; catfish, salmon and barramundi. The answer "yes" agrees that the species fits the criteria, "no" means it doesn't and "unsure" means not enough information is available to make a decision.

It could be argued that this using this process to validate the model is a self assessment. However, not only are results of the question *"Why is catfish/salmon/barramundi aquaculture successful?"* factored into the model, but so are the results from the more abstract questions; *"How would you specify the design of a new product? What should be the selection criteria for a new species and what attributes should an aquacultured fish have to survive and thrive in the marketplace?"* This broader and deeper qualitative research used to construct the Master Model contributes to its validity as an assessment tool. Some criteria in Table 6.4 require explanation in the context of the results of the present study. These are listed in Table 6.3.

Table 6.3 Criteria requiring explanation

Criterion	Explanation
1 Marketability	The ease by which the product is accepted and exchanged in the marketplace
6. Versatility of carcass use	How much use can be made of the species carcass
9. Availability	How often and regularly the product appears for sale
12. Easy to produce juveniles	The lifecycle is closed and there is a hatchery nearby operating efficiently. Juveniles for some species can be collected from the wild making them easy to produce.
19. Potential to value add	How much use may be made of the species carcass
24. Uniqueness	In the terms of the present study, uniqueness follows the dictionary definition as described by Hughes *et al.*, (1992)
25. Flexibility	A variety of production, processing and marketing options
31. Suitable to environment	Suitable to the environment in which the species is grown, for example a species native to the environment rather than one trans-located.
33 Innovative/ marketed in a new form	The species or its derivatives can be sold in a form not previously sold to the target market. A good example in the Australian market is the rapid uptake of sashimi.
43. Adaptable to environment	A species adaptable to an environment other than its own. For example the translocation of Atlantic salmon from the northern to the southern hemisphere.

Table 6.4 The Master Model applied to the benchmark species

Criterion/attribute/success factor	Rank	Catfish	Salmon	Barra	Assessed as
1. Marketability	**1**	Yes	Yes	Yes	Essential criteria
2. Adaptability to aquaculture/ease of farming	**2**	Yes	Yes	Yes	
3. Well priced/profitable	**3**	Yes	Yes	No	Highly important criteria
4. Short growth cycle time	**4**	Yes	Yes	Yes	
5. Market and consumer knowledge of species	**5**	Yes	Yes	Yes	
6. Versatility of carcase use	**6**	Yes	Yes	Yes	
7. Available technology	**6**	Yes	Yes	Yes	
8. Robust/environmentally tolerant	**7**	Yes	Yes	Yes	
9. Availability	**7**	Yes	Yes	Yes	
10. Economically produced	**8**	Yes	Yes	Yes	Important criteria
11. Good FCR (food conversion ratio)	**9**	Yes	Yes	Yes	
12. Easy to produce juveniles	**9**	Yes	Yes	Yes	
13. Disease and parasite resistant	**9**	Yes	No	No	
14. Quality	**9**	Yes	Yes	No	
15. Environmentally acceptable production	**10**	Yes	Yes	Yes	
16. Able to develop diet	**10**	Yes	Yes	Yes	
17. Attractive	**11**	No	Yes	Yes	
18. Shelf life	**11**	Yes	Yes	Yes	
19. Potential to value add	**11**	Yes	Yes	Yes	
20. Established or potential market	**12**	Yes	Yes	Yes	
21. Closed lifecycle	**12**	Yes	Yes	Yes	
22. Herbivorous	**12**	Unsure	No	No	
23. Euryhaline	**12**	No	No	Yes	
24. Uniqueness	**12**	Yes	Yes	Yes	
25. Flexibility	**12**	Yes	Yes	Yes	
26. High value or high volume market	**12**	Yes	Yes	No	
27. Customer safe perception	**13**	Yes	Yes	Yes	Relevant criteria
28. Competitive advantage	**13**	Yes	Yes	Yes	
29. Well marketed	**13**	Yes	Yes	No	
30. Fit the agribusiness value chain	**13**	Yes	Yes	Yes	
31. Suitable to environment	**13**	Yes	Yes	Yes	
32. Not easily duplicated	**14**	Unsure	Unsure	Unsure	
33. Innovative/marketed in a new form	**14**	Yes	Yes	Yes	
34. Government support	**14**	Yes	Yes	Yes	
35. Improvement on existing product	**14**	Yes	Yes	Yes	
36. Recovery rate/fillet yield	**14**	Yes	Yes	Yes	
37. Globally competitive/serve a global market	**14**	No	Yes	No	
38. Knowledge of biology/hatchery cycle	**14**	Yes	Yes	Yes	
39. Value	**15**	Yes	Yes	Yes	Noted criteria
40. Fashionable	**15**	Yes	Yes	Yes	
41. Similar species not grown overseas	**15**	No	No	No	
42. Shortage of supply	**15**	No	No	Yes	
43. Adaptable to environment	**15**	Yes	Yes	Yes	
44. Site availability	**15**	Yes	Yes	Yes	
45. Chemical free production	**15**	No	No	No	
46. Able to achieve first mover advantage	**15**	Yes	No	No	
47. Potential to become a mainstream fish	**15**	Yes	Yes	Yes	
48. Synergies with current operations	**15**	No	No	No	
49. Possessing scales	**15**	No	Yes	Yes	
50. Live market appeal	**15**	No	No	No	
51. Low mortality rate	**15**	Yes	Yes	Yes	
52. Advantage of produced in Australia	**15**	No	Yes	Yes	
53. Achieve a regular price	**15**	Yes	Yes	Yes	

All benchmark species met all essential selection criteria and all met the highly important criteria with the exception of barramundi which scored "no" for Criterion 3-'well priced/profitable.' Though surveyed as a benchmark species, were the classifications extrapolated from the results of the present study applied to barramundi it would be categorised as a Stage 4-'emerging species.' This means it appears successful but needs more time in the agribusiness value chain to prove beyond reasonable doubt its profitability and ability to achieve a good consistent price. Both salmon and barramundi are susceptible to disease and parasites and therefore fail Criterion 13. Catfish is relatively free of disease and parasites. Salmon and barramundi are carnivores and therefore fail Criterion 22-'herbivorous.' Catfish is often regarded as herbivorous but does have some fauna in its diet and rates as "unsure;" however, it could probably be reassessed as herbivorous. United States catfish serves a high volume market and Tasmanian salmon serves a high value market so they both pass Criterion 26. Barramundi serves a variety of segmented markets but has yet to embed these markets in its value chain. Barramundi also fails Criterion 29 because it is not yet well marketed but should eventually become so. All species rated "unsure" for Criterion 32-'not easily duplicated.' Assessing ease of duplication is particularly difficult because all benchmark species can be duplicated elsewhere but (possibly) without the competitive advantage created by their respective agribusiness systems in the United States South, Tasmania and northern Australia respectively. Atlantic salmon grown in Tasmania is still thought to be globally competitive (Criterion 37) but catfish has yet to exploit global opportunities, though it may have to in the face of competition from Viet Namese catfish imports and structural problems in the industry. Barramundi growers are still exploring Australian-grown barramundi's position in the global market. Similar species to the benchmarks are grown overseas (Criterion 41) and in the case of salmon and barramundi (=Asian sea bass) the same species is grown overseas. Channel catfish in the United States is a member of the *Ictaluridae* family, the dominant catfish family for aquaculture in the world. At present it appears that channel catfish will be grown on a large scale outside the United States, and China could be a future threat. No aquaculture production is entirely chemical free (Criterion 45) and no benchmark species have synergies with current operations as they are the focal operation themselves. None appear to have a live market appeal (Criterion 50) though this is an area for examination.

Applying the model

6.4.1 Snapper *(Pagrus auratus* Forster in Bloch and Schneider, 1801)

Source: Sydney Fish Markets http://www.sydneyfishmarket.com.au/

Snapper are native but not endemic to Australia and known as red sea bream in Asia and squirefish in some areas. Southern and northern hemisphere snapper stocks were once considered to be two separate species, *Chrysophrys auratus* and *Pagrus major*. However, they are now regarded as the one species *Pagrus auratus,* with independent and reproductively isolated populations in Japan and Australasia (Paulin, 1990)

Snapper are continuously, but apparently irregularly distributed around the southern coastline of continental Australia from Hinchinbrook Island in Queensland to Barrow Island in Western Australia and occasionally off the north coast of Tasmania, but no further south. Also widely distributed in the Indo-Pacific region, snapper live in warm temperate and subtropical waters. Juveniles inhabit inlets, bays and sheltered marine waters, often over mud and sea grass. Adults often live near reefs, but are also found near mud and sand substrates, inhabiting depths from less than one metre to 200 metres (Jones *et al.,* 1993).

Life history

Mature adults form large schools in preferred spawning areas and snapper spawn repeatedly during the breeding season in waters less than 50m deep with a surface temperature range between 18°C-21°C. Snapper populations in southern Australian waters spawn between late October and early March and in northern waters from late

May or early June to August. In a spawning season a three year old female may produce 250,000 eggs, a 1.5 kg female 300,000 eggs and a 10 year old female 5 million eggs (PIRSA, 2000). Fertilised eggs are thought to be buoyant and drift with the prevailing currents for several days before hatching. Juvenile snapper leave the mid-water zone to inhabit reefs when twelve months old and around 6cm long. In New South Wales, Victoria and South Australia older juveniles and young adults move to coastal and off shore waters and some fish travel large distances along the coastline. Snapper are a long lived and slow growing fish exhibiting variable growth rates across their distribution that may be related to local habitat. They (apparently) can live to 35 years, with 22 year old fish common in South Australia. Snapper 1.3m long and weighing 16kg have been recorded (Jones *et al.,* 1993). Snapper in Victorian waters eat crustaceans, bivalve molluscs and small fish. Juveniles and small adults in South Australia eat western king prawns *(Penaeus latisulcatus),* while larger fish feed on thick-shelled animals like blue swimmer crabs *(Portunus pelagicus)* and mussels (Jones *et al.,* 1993b).

Aquaculture

The following information is pertinent in assessing snapper's aquaculture potential.

1. In 1997, the estimated sales of snapper in New South Wales were 1,500 tonnes per annum. In the year ending June 2000, the commercial fishing sector caught only 279 tonnes of snapper. The difference was imported from New Zealand and Western Australia.
2. On 1 July 2000, the legal size limit for catching snapper in New South Wales was increased to 32 cm, driven by snapper wild catch falling from 900+tonnes in the early 1980s to just 279 tonnes in1999/2000.
3. The snapper fishery in New South Wales is over fished/depleted/unsustainable (NSW Fisheries Status of Fisheries Resources 1999/2000 New South Wales Fisheries www.fisheries.nsw.gov.au/aquaculture).
4. The Australian Fisheries Research and Development Corporation (FRDC) has estimated a possible shortfall between Australian demand and supply of seafood for human consumption of 80,000 tonnes by 2020 (Pisces Marine Aquaculture Prospectus, 2002).

Table 6.5 Snapper assessed against the Master Model

Criterion/attribute/success factor	Rank	Snapper	Assessed as
1. Marketability	**1**	Yes	Essential criteria
2. Adaptability to aquaculture/ease of farming	**2**	Yes	
3. Well priced/profitable	**3**	Unsure	Highly important criteria
4. Short growth cycle time	**4**	Unsure	
5. Market and consumer knowledge of species	**5**	Yes	
6. Versatility of carcase use	**6**	Unsure	
7. Available technology	**6**	Yes	
8. Robust/environmentally tolerant	**7**	Yes	
9. Availability	**7**	No	
10. Economically produced	**8**	Unsure	Important criteria
11. Good FCR	**9**	Yes	
12. Easy to produce juveniles	**9**	Yes	
13. Disease and parasite resistant	**9**	Unsure	
14. Quality	**9**	Unsure	
15. Environmentally acceptable production	**10**	Yes	
16. Able to develop diet	**10**	Yes	
17. Attractive	**11**	Yes	
18. Shelf life	**11**	Unsure	
19. Potential to value add	**11**	Unsure	
20, Serve an established or potential market	**12**	Yes	
21. Closed lifecycle	**12**	Yes	
22. Herbivorous	**12**	No	
23. Euryhaline	**12**	No	
24. Uniqueness	**12**	No	
25. Flexibility	**12**	No	
26. Serve a high value or high volume market	**12**	Unsure	
27. Customer safe perception	**13**	Yes	Relevant criteria
28. Competitive advantage	**13**	Unsure	
29. Well marketed	**13**	Unsure	
30. Fit the agribusiness value chain	**13**	Unsure	
31. Suitable to environment	**13**	Yes	
32. Not easily duplicated	**14**	No	
33. Innovative/marketed in a new form	**14**	No	
34. Government support	**14**	Yes	
35. Improvement on existing product	**14**	Unsure	
36. Recovery rate/fillet yield	**14**	Unsure	
37. Globally competitive/serve a global market	**14**	No	
38. Knowledge of species biology/hatchery cycle	**14**	Yes	
39. Value	**15**	Unsure	Noted criteria
40. Fashionable	**15**	Unsure	
41. Similar species not grown overseas	**15**	No	
42. Shortage of supply	**15**	Yes	
43. Adaptable to environment	**15**	Yes	
44. Site availability	**15**	No	
45. Chemical free production	**15**	Unsure	
46. Able to achieve first mover advantage	**15**	No	
47. Potential to become a mainstream fish	**15**	Yes	
48. Synergies with current operations	**15**	Yes	
49. Possessing scales	**15**	Yes	
50. Live market appeal	**15**	Yes	
51. Low mortality rate	**15**	Yes	
52. Advantage of being produced in Australia	**15**	Yes	
53. Achieve a regular price	**15**	Unsure	

The pioneering snapper companies were probably undercapitalised and may not have been structured correctly to grow a new species. This is not a criticism, but a set of circumstances which often occurs with new species ventures. (Dr Stewart Fielder, New South Wales Fisheries, personal communication, 1 July 2003).

The results of the present study place snapper as a new species (Stage 3).

Essential criteria

Criterion 1 Marketability

Yes.

Market demand and the ability to produce an affordable product are the two main criteria for success, with the market the key driver of the two (Hussey, 1999). The commercial snapper fishery is the third most valuable after sea mullet and bream and snapper sells for between $10-$15 kilo in the Sydney Fish Markets (New South Wales Fisheries www.fisheries.nsw.gov.au/aquaculture). According to Ruello and Associates (2000) barramundi and snapper remained the favourite for dining out in Sydney and Perth during the 1990s. Aquacultured market size snapper (~450kg) achieve $9.00-$12.00 kg (whole/dead) and up to $14.00 for live fish in Sydney's Chinatown (Fielder, 2001).

About 1500 tonnes of snapper are sold in New South Wales each year. The local catch has fallen from 9000+ tonnes in 1982 to 300 tonnes in 1996. 1200 tonnes of snapper are being imported from New Zealand and Western Australia each year to meet this deficit. At $10 per kilo that equates to $12 million annually (New South Wales Fisheries). This imported snapper was estimated to have risen to 1, 377 tonnes by Weston *et al.,* (2001). In weekly sales of 400-700kg fish, Pisces Marine Aquaculture (PMA) achieves a farm gate price of $10.50-$11.50kg depending on order size. There is a market demand for a farmed fish consistently sized, supplied regularly at a stable price. (http://www.pisces.com.au)

O'Sullivan (2000) reported that when establishing, PMA started with the market and worked backwards to the production function in a technique known as chain reversal (Folkerts and Koehorst, 1997). Their agribusiness value chain survey included chefs, retailers, caterers, supermarket buyers and exporters who were asked classic market assessment questions covering size, colour, post harvest technology and handling and *what point of entry into the distribution chain the company should take.* PMA then set about producing a fish matching the requirements gleaned in their early market survey.

Criterion 2 Adaptability to aquaculture/ease of farming

Yes.

New South Wales Fisheries established by 1995 that adequate numbers of fingerlings could be regularly produced using intensive hatchery methods and snapper would grow to market size in cages. When this information was presented to prospective snapper farmers in New South Wales (June 1995), the South Australian (SA) Research and Development Institute (SARDI) and the Western Australian Fishing and Aquaculture Centre (WAFAC) had commenced parallel programmes for snapper aquaculture. In 2001 SA had two land based hatcheries and three operating commercial sea cage farms with one new farm under development all located in Spencers Gulf. Western Australia has one privately operated hatchery and sea cage farm at Jurien Bay (Fielder, 2001).

New South Wales has two commercial floating sea cage farms; a trial farm, Silver Beach Aquaculture Pty Ltd in Botany Bay (Lyall, 1998; Fielder, 2001) and Pisces Marine Aquaculture (PMA) off shore from Port Stephens at Cabbage Tree Island, two and one half hours drive north of Sydney (O'Sullivan, 2000: O'Sullivan, 2001). Both operations sourced their fingerlings from the former prawn and shellfish marine hatchery at Brooms Head north of Port Stephens (Lyall, 1998; O'Sullivan, 2001).

Highly important criteria

Criterion 3 Well priced/profitable

Unsure.

In the Melbourne Fish Markets on Wednesday 21 May 03 wild caught snapper achieved a price of $10/kilo (high), $6.00/kilo (low) averaging $7.50 /kilo (low) with 30 bins sold (see http://www.chsmith.com.au/fish-prices/index.htm). In the Sydney Fish Markets on 4 Jul 03 snapper presented in a variety of ways from HOGG to whole fish received prices ranging from $7.62 to $13.34/kilo (http://www.sydneyfishmarket.com.au)

Criterion 4 Short growth cycle time

Unsure.

Snapper has a slow growth rate in the wild, taking 3-5 years to reach market size of 28cm and average weight of 400g. (Last *et al.,* 1999; New South Wales Fisheries www.fisheries.nsw.gov.au/aquaculture). PMA snapper grow to 500g 18 months (Dr Stewart Fielder, New South Wales Fisheries, personal communication, 1 July 2003) and according to PMA's Prospectus this is twice the grow rate in the wild. (PMA Prospectus 2002)

In South Australia all but one company Franklin Harbour Finfish Farm has switched from snapper to yellowtail kingfish because aquacultured yellowtail kingfish grow to 3kg in 14-15 months and 5kg in 22-25 months, whereas snapper in South Australia struggle to reach 500 g in 18 months. Fast growth rate is most important. Yellowtail kingfish fetch the same or similar price to snapper but achieve sale size in less time. (Wayne Hutchinson, Senior Research Scientist, Coastal Finfish Aquaculture PIRSA-SARDI, 27 May, 2003 personal communication)

Criterion 5 Market and consumer knowledge of species

Yes.

PMA selected snapper in 1995 because it was the most widely recognised fish in Australia or Asia. (PMA Prospectus, 2002). "The marketing name snapper has been retained on a (sic) historical basis. This fish should not be confused with the true snappers or sea perches *(Lutjanidae).* One of Australia's most highly regarded food fishes." (Last *et al.,* 1999). Snapper are landed at sizes between 0.8-8 kg and produce a deep, long slightly pink fillet without dark veins which tapers off at one end (Last *et al.,* 1999).

Criterion 6 Versatility of carcass use

Unsure.

Current demand is for one whole fish per plate. PMA currently grow fish out to 450g (30 cm) over 12-18 months. (PMA Prospectus 2002). The versatility of aquacultured snapper's carcass is yet to be demonstrated.

Criterion 7 Available technology

Yes.

Like two of the benchmarks, barramundi and salmon, snapper's technology was imported. Snapper were first artificially bred in Japan which now produces around 70,000 tonnes per year (Liska, 1999). The Australian snapper industry was developed using technology and techniques employed to grow red sea bream in Europe and Japan, adapted to Australian conditions (Weston *et al.,* 2001). The red sea bream aquaculture value chain was initiated in Japan around 1970 by development of methods for artificial mass production of fry, delivering a stable supply of juveniles, culture technology enabling growout to a saleable size of one kilogram (within two and a half to three years) and research and development into composite feeds and feeding methods (PIRSA, 2000).

Criterion 8 Robust/environmentally tolerant

Yes.

Appears robust and tolerant. Has a large geographical spread

Criterion 9 Availability

No.

There is a substantial snapper supply shortfall to markets in Australia with catches in New South Wales falling from 1000 tonnes in 1980 to 307 tonnes 1997-1998. Approximately 1000 tonnes was imported from New Zealand in1998. Live fish export from Australia has increased from $AUD 4.6 million in 1992-93 to $AUD 16.0 in 1997-98 and a high value domestic market ($14.50-$17.00/kg) for live snapper in eastern Australia exists (Fielder, 2001). Weston *et al.,* (2001) reported 2 tonnes production in 1996-7 and 5 tonnes in 1997-8. O'Sullivan estimated the 1997-1998 production from aquaculture as 5 tonnes and Fielder reported South Australian production of 10-15 tonnes, thought to be for 1998-1999 (CRC, 2000). New South Wales farm production is estimated as 30 tonnes in 2000-2001 and 500 tonnes in 2002-2003. (www.fisheries.nsw.gov.au/aquaculture). PMA sold 30 tonnes in 2001-2002 valued at $270,000 and expect to sell 50 tonnes in 2002-2003 with a projected value of $350,000. The snapper average $9.00/kilo, but can fetch up to $12.50/kilo. The company's price if it were to dump fish on the market is $7.00/kilo. (Andrew Bald, Chairman, Pisces Marine Aquaculture, personal communication)

There is a shortfall of snapper supply overall, but not as yet an expansion ratio as described by New (1999) of aquacultured fish to indicate a rapid uptake of snapper aquaculture. The question here is not so much the availability of snapper as such but the availability of aquacultured snapper that would indicate a strong market penetration and consumer acceptance of farmed fish. This is yet to be seen.

Criterion 10 Economically produced

Unsure.

Cost of production for aquacultured snapper is around $8.50/kg and snapper sell for around $10/kg, therefore profit can be reckoned on around $1.50/kg. The problem with snapper aquaculture is economies of scale which could bring about economies in the agribusiness value chain resulting in lower production costs. (Dr Stewart Fielder, New South Wales Fisheries, personal communication, 1 July 2003).

The results of the present study indicate that two of the benchmarks, catfish and salmon have achieved industrial status. The barramundi results indicate the importance of price points above which consumers will not go. Industrialisation lowers cost of production and therefore the end price to consumers is lowered. Snapper's cost of production and current limited capacity to industrialise are probably the industry's biggest restriction on achieving measurable expansion ratios. Building a large scale mariculture industry on a single species appears risky but; Greece produces 80,000 tonnes/year of sea bass and sea bream, Japan produces 80,000 of sea bream, Turkey built a 10,000 tonne sea bass industry in ten years and Tasmania (Australia) built a 10,000 tonne Atlantic salmon industry in twelve years. (Rogers, 1999).

Important criteria

Criterion 11 Good FCR

Yes.

Snapper take artificial diet easily and can covert pellets with 42% fishmeal protein to flesh at a feed conversion ratio (FCR) of 2:1. (New South Wales Fisheries www.fisheries.nsw.gov.au/aquaculture).

Criterion 12 Easy to produce juveniles

Yes.

However, both Liszka (1999) and Fielder (2001) identified a supply of cheap vigorous juveniles as a problem with snapper aquaculture. The PMA hatchery is not currently operating but if upgraded will produce one million fingerlings per year by 2005 (PMA Prospectus 2002). New South Wales Fisheries at Port Stephens currently produces fingerlings for PMA aiming for a price of 50cents/fish with the intention of reducing the price to 25 cents by more intensive rearing. NSW Fisheries is examining implementation of the Darwin Aquaculture Centre/Marine Harvest barramundi model in the Northern Territory to produce both snapper and mulloway fingerlings under contract for PMA. (Dr Stewart Fielder, New South Wales Fisheries, personal communication, 1 July 2003).

Criterion 13 Disease and parasite resistant

Unsure.

"Epidemic diseases caused by organisms such as ciliated protozoan and monogenean trematodes, have killed juvenile and adult snapper and mulloway. Heavy mortality can occur if diseases are left untreated and during weaning and at other times when fish are stressed." (NSW Fisheries www.fisheries.nsw.gov.au/aquaculture).

Developing a new species as a hedge against species-specific diseases is a valid reason for diversification in Australia, but how valid is uncertain because the survey respondents did not attach importance to this factor, probably because of Australia's lesser problems with disease than other countries growing fish in aquaculture.

Criterion 14 Quality

Unsure

Farmed snapper is a slightly different shape with darker skin than wild snapper, creating concern about medium term market acceptance (Weston *et al.,* 2001). O'Sullivan (2001) reports PMA shades the fish for a few weeks before harvest to encourage the natural colour to emerge and acknowledges that a special diet assists in pigmentation restoration. Flesh discolouration or sunburn in snapper (PMA Prospectus 2002) has been highlighted in the media (Limb, 2001; Lawson, 2003). According to data collected in 2002, consumers favoured the "pinky silvered" colour of wild snapper which are fetching $2.00 more per kilo than aquacultured snapper (Lawson, 2003). This is an appearance problem which will be overcome, but like the perception of barramundi as being either freshwater or saltwater, a slight flesh discolouration may not only turn customers away, but be used as a bargaining tool to lower prices of farmed snapper. Fielder (2001) identified addressing aquacultured snapper's dark skin pigmentation either by dietary supplements or environmental manipulation as a research and development priority (Fielder, 2001).

Criterion 15 Environmentally acceptable production

Yes.

All aquaculture should meet the criteria of triple-bottom-line accounting; economically successful, environmentally sustainable and socially beneficial. The evidence suggests PMA has done what the results said, that is to over comply with environmental regulations. However the ABC Rural Affairs Landline highlighted concerns held by environmentalists and a professional fisherman about the effects of Pisces operations (Limb, 2001). A rigorous study was undertaken Hoskin and Underwood (2001) to assess potential the ecological effects of offshore snapper farming in Providence Bay, New South Wales. They concluded from two manipulative experiments that there was some environmental impact underneath PMA's snapper cages in Providence Bay and that planned increases in cage numbers and snapper production were "likely to increase the potential for and extent of ecological impacts." Future monitoring experiments should be sufficiently similar to present experiment in order to detect the same kinds of potential impacts and "future monitoring should be designed to be able to evaluate better whether ecological impacts persist and accumulate over time, or are mostly transient. Finally, any ecological impacts that snapper farming has caused in Providence Bay, or which might occur in the future would probably recover very quickly in any area where production ceases. There was no evidence that snapper farming has caused the local extinction of any type of animal or the appearance of any other type of animal that was not already present. At the scale of annual production planned by PMA, despite some evidence for impacts, it is unlikely the farm could cause irreversible environmental or ecological changes on the seabed." This study shows the application of the Precautionary Principle as described by Bartley (1998).

Criterion 16 Able to develop diet

Yes.

Though snapper is a carnivore work is ongoing to improve its diet at all stages of growth especially to reduce the species dependence on fishmeal (Dr Stewart Fielder, New South Wales Fisheries, personal communication, 1 July 2003).

The survey results indicated a new species should be either herbivorous, have a low intake of fish oil and fish meal, or be capable of adjusting to a diet of made up of proteins from flora. Under culture, snapper suffer a high mortality rate at 12-17mm long, 30-40 days after hatching which may be related to a diet deficiency, an area of ongoing research. Depending on the farmer's preference, snapper are fed a floating or sinking pellet diet composed of about 45% protein and 15% lipid (Fielder, 2001). PMA feed the snapper Skretting high protein and low protein barramundi diet and Ridley's barramundi diet. The fish also eat natural food such as prawns and crabs which live in the vicinity of the farm (O'Sullivan, 2001). Fielder (2001) identified developing feeds specific to snapper's diet requirements as an immediate research and development issue.

Criterion 17 Attractive

Yes.

Snapper is "one of Australia's most highly regarded food fishes." (Last *et al.*, 1999).

Criterion 18 Shelf life

Unsure.

No reference is available but aquacultured snapper appears to have a reasonable shelf life

Criterion 19 Potential to value add

Unsure.

Most snapper is eaten whole or in fillets. This may be an issue for product development.

Criterion 20 Serve an established or potential market

Yes.

Criterion 21 Closed lifecycle

Yes.

Criterion 22 Herbivorous

No.

Snapper is a carnivore, but with diet development snapper's reliance on animal protein may be replaced by vegetable proteins.

Criterion 23 Euryhaline

No.

Though snapper is a marine fish it is estuarine the juvenile phase of its life and may be able to cope with wider salinities than currently thought acceptable.

Criterion 24 Uniqueness

No.

Snapper is native but not endemic to Australia.

Criterion 25 Flexibility

No.

In terms of the results flexibility means a range of production and marketing options. Snapper does not appear to have the flexibility of the benchmarks, nor does it meet the criterion of flexibility.

Criterion 26 Serve a high value or high volume market

Unsure.

In Australia the market is currently neither high value nor high volume.

Relevant and Noted Criteria

Tables 6.6 and 6.7 list the Relevant and Noted criteria with appropriate comment

Table 6.6 Snapper relevant criteria

Criterion	Rank	Snapper	Comment
27. Customer safe perception	**13**	Yes	Assumed as a given. PMA has worked hard on this aspect of its image.
28. Competitive advantage	**13**	Unsure	Species not unique to Australia and is produced overseas. Insufficient information for assessment
29. Well marketed	**13**	Unsure	Insufficient information for assessment
30. Fit the agribusiness value chain	**13**	Unsure	Snapper needs a strong research base to refine technology with the aim of reducing production costs. The industry has to properly configure its agribusiness value chain starting with a reliable supply of high quality eggs for hatchery production of juveniles, increase hatchery output and reduce the cost of fingerling production using intensive and extensive larval rearing. (Fielder *et al.,* 1999; Fielder, 2001) The industry needs to develop appropriate technology for new farming sites. (Fielder 2001)
31. Suitable to environment	**13**	Yes	Snapper occurs naturally where it is farmed (Last *et al.,* 1999). Snapper aquaculture started in 1995-96 in South Australia. All but one company has switched to Yellowtail kingfish because snapper grows too slowly in an area at the end of its southern range for aquaculture. However Sunaqua has decided to grow snapper near Tangalooma (behind Moreton Island in Queensland towards the northern limit of snapper's aquaculture range. (Dr Stewart Fielder, New South Wales Fisheries, personal communication, 1 July 2003).
32. Not easily duplicated	**14**	No	Grown in many areas other than Australia. But if snapper aquaculture were easily duplicated in Australia the uptake may be substantial and expansion ratios evident It may be a function of profitability
33. Innovative/ marketed in a new form	**14**	No	Value adding needs exploration. There is limited snapper new product development.
34. Government support	**14**	Yes	CRC and FRDC
35. Improvement on existing product	**14**	Unsure	Demand for wild caught snapper is strong, but growing to size in aquaculture conditions is important for a plate sized (fish) market

Criterion	Rank	Snapper	Comment
36. Recovery rate/fillet yield	**14**	Unsure	Aquacultured snapper is grown to plate size and eaten as a whole fish. Quéméner *et al.*, (2002) identified a European trend towards fish with high carcass yields. Australian snapper growers could emulate this trend
37. Globally competitive/serve a global market	**14**	No	Much snapper is grown overseas and it appears aquaculture snapper's best short term prospect is import replacement.
38. Knowledge of species biology/hatchery cycle	**14**	Yes	Very well known in Australia and overseas

Table 6.7 Snapper noted criteria

Criterion	Rank	Snapper	Comment
39. Value	**15**	Unsure	Insufficient information
40. Fashionable	**15**	Unsure	Insufficient information
41. Similar species not grown overseas	**15**	No	Snapper is native but not endemic to Australia and grown extensively overseas.
42. Shortage of supply	**15**	Yes	Australian demand is currently underwritten by imports from New Zealand
43. Adaptable to environment	**15**	Yes	No averse reports on snapper's adaptability
44. Site availability	**15**	No	The criteria of site availability rated at number 44 is because survey respondents thought of sites as a given; an assumption that sites are not a big issue because no sites=no aquaculture. However Liszka (1999) and Fielder (2001) identified access to grow out sites as a problem. Earlier Jungalwalla (1991) observed lack of sites as a general inhibitor to aquaculture. It is difficult to work out which is the inhibitor to snapper's expansion, lack of uptake in the market place or lack of sites. "Expansion of the sea cage based industry, particularly on the East Coast of Australia may be limited by the lack of sites with suitable water quality, depth and proximity to land based infrastructure. Conflict with other waterway users and perceived concerns about environmental impact have already affected approval of commercial sea cage farms. However vast inland areas with saline water may offer additional sites for farming marine species." (Fielder, 2001).
45. Chemical free production	**15**	Unsure	Insufficient information available for assessment
46. Able to achieve first mover advantage	**15**	No	No
47. Potential to become a mainstream fish	**15**	Yes	Already mainstream due largely to its popularity in the recreational fishery
48. Synergies with current operations	**15**	Yes	PMA grow mulloway alongside snapper which appears synergic

Criterion	Rank	Snapper	Comment
49. Possessing scales	**15**	Yes	Biologically a scaled fish (Last *et al.,* 1999)
50. Live market appeal	**15**	Yes	Snapper has potential for live trade on the domestic and export market (Fielder, 2001). Snapper has proven suitable for the live trade *to wit* PMA set a live shipment of 54kg to the United States and only four fish died in transit Snapper can be co-confined in live holding tanks with abalone, lobsters or other finfish (O'Sullivan, 2001).
51. Low mortality rate	**15**	Yes	Insufficient information available
52. Advantage of being produced in Australia	**15**	Yes	Australia appears to have a good international image
53. Achieve a regular price	**15**	Unsure	The price fluctuates but could be partially stabilised with better supply chain management.

Conclusion

Snapper was selected and developed for sound reasons. The species is popular, adaptable to farming as the extensive culture of red sea bream has proven overseas, and it has a market in Australia, gaps in which are often filled by imported snapper from New Zealand. The application of any model may have assessed snapper suitable for aquaculture. However, as any farmed flora or fauna industry ages, unforeseen problems emerge which impact on that industry's short and long term viability. Snapper, though relatively young in Australia is, when juxtaposed with the model, showing areas for concern. One indicator of a species success is an expansion ratio as described by New (1999). The snapper industry has not expanded but contracted. In 2001, Weston *et al.,* noted South Australian snapper farmers were experimenting with yellowtail kingfish *(Seriola lalandi)* as a quicker growing, but lower priced alternative to snapper, although in the same year Nick Ruello argued yellowtail kingfish were receiving a better price (Nick Ruello, Ruello and Associates, personal communication, 5 Aug 01). In 2003, only one snapper farm (Franklin Harbour Finfish Farm) remained in production in South Australia and one (PMA) in New South Wales. The reason South Australian farmers' switched species was that in their assessment, yellowtail kingfish appeared a better species to grow. Snapper grew too slowly and appeared less (potentially) profitable than yellowtail. In New South Wales, a current problem exists with juvenile production that may be overcome by adoption of the Northern Territory barramundi model for the state government to produce juveniles under contract. The physical appearance of farmed snapper is dissimilar in shape and colour from its wild counterpart and is therefore perceived to be less attractive. Overcoming farmed snapper's "sun burn" is an issue for further industry research and development, a task currently underway. Farmed snapper is neither unique, nor appears as flexible in production, processing and marketing compared to other farmed species, for example Atlantic salmon and barramundi. From an agribusiness viewpoint, production is small scale, and whether sites are limited or not, uptake of snapper aquaculture to produce an expansion ratio, economies of scale, and decreasing cost of production, leading to industrial production remains elusive. Somewhere in the species' agribusiness value chain a competitive advantage needs building in. Larger scale production would increase snapper's availability and make possible a marketing campaign to lift its image. However the product development literature clearly says that a sustained marketing campaign cannot occur without sustained back up from large amounts of good quality product. Catfish won the marketing battle on this basis. The marketing campaign was backed by limitless supplies of good quality product.

6.4.2 Yellowtail kingfish *(Seriola lalandi* Valenciennes, 1833)

Source: Australian Hiramasa http://www.australianhiramasa.com/main.asp/

Yellowtail kingfish are native but not endemic to Australia. They are a circumtropical species globally distributed in the Pacific and Indian oceans off South Africa, Japan, southern Australia and the United States of America from 54° N to 43° S in temperatures ranging from 18-24° C at depths to 50 metres. (Smith *et al.,* 1993; www.fishbase.org; www.pir.sa.gov.au). Table 6.8 assesses yellowtail kingfish against the Master Model.

Table 6.8 Yellowtail kingfish assessed against the Master Model

Criterion/attribute/success factor	Rank	Yellowtail kingfish	Assessed as
1. Marketability	1	Unsure	Essential criteria
2. Adaptability to aquaculture/ease of farming	2	Unsure	
3. Well priced/profitable	3	Unsure	Highly important criteria
4. Short growth cycle time	4	Yes	
5. Market and consumer knowledge of species	5	Yes	
6. Versatility of carcase use	6	Yes	
7. Available technology	6	Yes	
8. Robust/environmentally tolerant	7	Yes	
9. Availability	7	Yes	
10. Economically produced	8	Yes	Important criteria
11. Good FCR	9	Yes	
12. Easy to produce juveniles	9	Yes	
13. Disease and parasite resistant	9	No	
14. Quality	9	Yes	
15. Environmentally acceptable production	10	Unsure	
16. Able to develop diet	10	Yes	
17. Attractive	11	Unsure	
18. Shelf life	11	Unsure	
19. Potential to value add	11	Yes	
20, Serve an established or potential market	12	Yes	
21. Closed lifecycle	12	Yes	
22. Herbivorous	12	No	
23. Euryhaline	12	No	
24. Uniqueness	12	No	
25. Flexibility	12	Unsure	
26. Serve a high value or high volume market	12	Yes	
27. Customer safe perception	13	Yes	Relevant criteria
28. Competitive advantage	13	Unsure	
29. Well marketed	13	Unsure	
30. Fit the agribusiness value chain	13	Yes	
31. Suitable to environment	13	Yes	
32. Not easily duplicated	14	No	
33. Innovative/marketed in a new form	14	Yes	
34. Government support	14	Yes	
35. Improvement on existing product	14	Unsure	
36. Recovery rate/fillet yield	14	Yes	
37. Globally competitive/serve a global market	14	Yes	
38. Knowledge of species biology/hatchery cycle	14	No	
39. Value	15	Unsure	Noted criteria
40. Fashionable	15	Yes	
41. Similar species not grown overseas	15	No	
42. Shortage of supply	15	No	
43. Adaptable to environment	15	Yes	
44. Site availability	15	Yes	
45. Chemical free production	15	No	
46. Able to achieve first mover advantage	15	No	
47. Potential to become a mainstream fish	15	Yes	
48. Synergies with current operations	15	Yes	
49. Possessing scales	15	Yes	
50. Live market appeal	15	Unsure	
51. Low mortality rate	15	Unsure	
52. Advantage of being produced in Australia	15	Yes	
53. Achieve a regular price	15	Unsure	

Life history and aquaculture

Yellowtail kingfish appear to be pelagic spawners that move offshore to spawn at around the age of two years. In Australia spawning occurs in July off Coffs Harbour, in October off Greenwell Point (New South Wales) and in February off Narooma (NSW). The eggs are pelagic, about 1.4mm diameter and hatch within 2-3 days and average 4mm long at the larval stage. The species grows to at least 1.9 m long and can weigh 70kg. The largest fish taken are usually around 1m long weighing 10-25kg. They are opportunistic daytime feeders, consuming small fish, squid *(Ommastrephidae)* and crustaceans. Yellowtail kingfish are both pelagic and demersal. (Smith *et al.,* 1993; www.fishbase.org; Gillanders *et al.,* 1999; Poortenaar *et al.,* 2001). Yellowtail kingfish is a new species which has operational, production and financial data available and predictions on its future performance.

Essential criteria

Criterion 1 Marketability

Unsure.

Opinion varies on yellowtail kingfish's market appeal. Anglers rate the species fighting qualities well but some regard the flesh as having a strong flavour with soft texture that does not hold its quality after landing (http://members.iinet.net.au/). Smith *et al.,* (1993) state the species is marketed as whole gilled and gutted fish and sold on the domestic market in cutlet or fillet form with the better quality fish sold for sashimi. This is supported by Last *et al.,* (1999) who noted; "small individuals (are) considered excellent eating, premium grade fish are used for sashimi. Good smoking qualities." Anecdotal evidence in industry newsletters also supports these latter observations. In 2001, Weston *et al.* observed that South Australian snapper farmers were experimenting with yellowtail kingfish *(Seriola lalandi)* as quicker growing, but lower priced alternative to snapper. In 2003 the snapper farmers with one exception have converted to yellowtail kingfish in South Australia. (Wayne Hutchinson, Senior Research Scientist, Coastal Finfish Aquaculture PIRSA-SARDI, 27 May, 2003 personal communication). The results of the present study indicated the species had two problems; slow growth and lack of market appeal. This is at odds with snapper farmers reasons for switching to yellowtail. It may mean that though yellowtail grows slowly, the species grows faster than snapper. This can only be assessed over a period of time, suggesting a re-assessment after yellowtail kingfish has a longer track record. That snapper farmers switched species to yellowtail is significant.

Criterion 2 Adaptability to aquaculture/ease of farming

Unsure.

A closely related species, Japanese amberjack *(Seriola quinqueradiata* Temminck and Schlegel 1845) forms the basis of a large aquaculture industry in Japan which produces over 150,000 tonnes, contributing over 90% of the total aquacultured marine finfish production in Japan. Several other more valuable species are also cultivated in Japan, notably *S. lalandi* (yellowtail kingfish) which rates highest as a sashimi grade fish especially during the northern hemisphere summer because of its low fat content. The species grows well at higher temperatures achieving up to 2.5 kg in one year. However, smaller yellowtail kingfish from colder waters are considered better quality, a variable that favours their culture in South Australia. Overall the species adapts well to sea cage culture (PIRSA, 2002). Therefore a choice exists between warm water, fast growth and colder water, slower growth but better quality. This success augurs well for aquaculture in Australia where it appears the species is adaptable and easy to farm. Four farms operate in South Australia:

1. South Australian Aquaculture Management at Fitzgerald Bay near Whyalla (four leases)
2. Southern Star at Fitzgerald Bay (one lease)
3. Navaho at Port Lincoln
4. Clean Seas Aquaculture at Arno Bay

These companies are represented by the South Australian Marine Finfish Farmers' Association and expect to produce 3000 tonnes of yellowtail kingfish in 2003. (Wayne Hutchinson, Senior Research Scientist, Coastal Finfish Aquaculture PIRSA-SARDI, 27 May, 2003 personal communication). This figure may be optimistic and a more realistic figure is 3000 tonnes for the calendar year 2005 (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).

Important criteria

Criterion 3 Well priced/profitable

Unsure

Yellowtail kingfish fetched $7.50 in the Melbourne Fish Markets on 1 Jul 03 (see http://www.chsmith.com.au/fish-prices/index.htm). Yellowtail kingfish fetched $7.90 to $10.93 (depending on size) in the Sydney Fish Markets on 2 Jul 03. (http://www.sydneyfishmarket.com.au)

Criterion 4 Short growth cycle time

Yes.

In South Australia all but one company (Franklin Harbour Finfish Farm), have switched from snapper to yellowtail kingfish because aquacultured yellowtail kingfish grow to 3kg in 14-15 months, and 5kg in 22-25 months, whereas snapper in South Australia struggle to reach 500 g in 18 months. Fast growth rate is viewed as most important. Yellowtail kingfish fetch the same or similar price to snapper but achieve sale size in less time. (Wayne Hutchinson, Senior Research Scientist, Coastal Finfish Aquaculture PIRSA-SARDI, 27 May, 2003 personal communication). Other data supports this growth rate; 1kg in six months, 3.5 kg in 18 months and 5.5 kg in 30 months. (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).

Criterion 5 Market and consumer knowledge of species

Yes.

Yellowtail kingfish is well known in Australia and overseas.

Criterion 6 Versatility of carcass use

Yes

Marketed whole, gilled and gutted or as cutlets or fillets. Premium grade fish are used for sashimi. Good smoking qualities (Last *et al.,* 1999)

Criterion 7 Available technology

Yes.

Readily available in Japan and developing in Australia.

Criterion 8 Robust/environmentally tolerant

Yes.

A relatively hardy fish when past the larval stage (PIRSA, 2002).

Criterion 9 Availability

Yes.

A South Australian industry participant and a South Australian scientist provided the following estimates noting at the time that the industry was only in a trial stage.

Table 6.9 Yellowtail kingfish production projections

	Industry participant		Scientist	
Year	Production in tonnes	Value $000	Production in tonnes	Value $000
2000	100	1,200	60	not given
2005	1,000	10,000	2,000	not given
2010	2,000	18,000	5,000	not given

Source: Cooperative Research Centre (CRC) for Aquaculture production estimates for minor finfish species, (2000).

The scientist commented that his initial figure was more conservative, due largely to unforeseen problems arising through lack of experience, for example fish losses and that his long term forward predictions are a combination of estimates and guesses. In 2000 it was not known which would be limiting variables, markets or availability of suitable sites. (CRC, 2000).

Criterion 10 Economically produced

Yes.

Table 6.10 Yellowtail kingfish cost of production and return

Age	Size	Cost of Production/kg	Selling price/kg
6 months	1 kg	c. $4-$5	$6.00
18 months	3.5 kg	c. $6.00	$7.50
24 months	5.5 kg	c. $7.00	$8-$9

Source: Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication.

Criterion 11 Good FCR

Yes.

FCR for yellowtail kingfish in South Australia is 1.75:1. (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 4 July 2003, personal communication). Related species achieve FCRs from 2:1 to 2.5:1 (Yellowtail Kingfish Aquaculture in SA Fact Sheet www.pir.sa.gov.au).

Criterion 12 Easy to produce juveniles

Yes

The Port Lincoln based company in South Australia, Australian Hiramasa produces disease free juveniles in marine hatcheries (www.australianhiramasa.com; Hoj *et al.,* 2002). Hatchery supply needs reliability and volume of supply. (Yellowtail Kingfish Aquaculture in SA Fact Sheet www.pir.sa.gov.au). Currently two hatcheries operate in Australia (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 4 July 2003, personal communication).

Criterion 13 Disease and parasite resistant

No.

Yellowtail is vulnerable to skin and gill fluke *(Monogea)* the management of which is treatment by bathing in diluted hydrogen peroxide. Also there are occasional bacterial outbreaks of *Vibrio* species (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 and 4 July 2003, personal communications). The species may also be susceptible imported disease, for example Japan has a problem with *Iridovirus* introduced from South East Asia (PIRSA, 2002).

Criterion 14 Quality

Yes.

It can be assumed that the quality is satisfactory as the species is well received by chefs in Sydney, arguably Australia's largest seafood market. (Glenn Hurry, General Manager, Fisheries and Aquaculture, Australian Department of Agriculture, Fisheries and Forestry (AFFA) 18 July 2003, personal communication).

Criterion 15 Environmentally acceptable production

Unsure.

It can probably be assumed that production is environmentally acceptable, although a perception issue exists about the effect of escaped fish on the local ecology. (Professor Ned Pankhurst, Head, School of Aquaculture, University of Tasmania at Launceston, 18 July 2003, personal communication)

Criterion 16 Able to develop diet

Yes.

Formulated feed especially for yellowtail kingfish (45:20 protein oil) is supplied by Skretting and Ridley. (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).

Criterion 17 Attractive

Unsure.

Criterion 18 Shelf life

Unsure.

Criterion 19 Potential to value add

Yes

Small individuals (are) considered excellent eating, premium grade fish are used for sashimi. Good smoking qualities (Last *et al.,* 1999).

Criterion 20 Serve an established or potential market

Yes.

Global market is established.

Criterion 21 Closed lifecycle

Yes

Criterion 22 Herbivorous

No.

Yellowtail kingfish is a carnivore (Smith *et al.,* 1993)

Criterion 23 Euryhaline

No.

Yellowtail kingfish is a marine species (Smith *et al.,* 1993)

Criterion 24 Uniqueness

No.

The species is grown overseas and is also known as yellowtail amberjack, gold striped amberjack and hiramasa. *Seriola dumerili* (greater amberjack or simply amberjack) is also grown overseas along with *Seriola quinqueradiata* (yellowtail or Japanese amberjack) the basis of the Japanese industry. (www.australianhiramasa.com; www.fishbase.org)

Criterion 25 Flexibility

Unsure.

Yellowtail kingfish should be flexible as it is successful overseas, but it needs more time to establish a track record in Australia.

Criterion 26 Serve a high value or high volume market

Yes.

This species can do both and is a top class producer of sashimi. (Yellowtail Kingfish Aquaculture in SA Fact Sheet www.pir.sa.gov.au; Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).

Relevant and Noted Criteria

Tables 6.11 and 6.12 list the Relevant and Noted criteria with appropriate comment

Table 6.11 Yellowtail relevant criteria

Criterion	Rank	Yellowtail	Comment
27. Customer safe perception	**13**	Yes	No reports are evident of pollution problems around potential sites, nor is there evidence of wild caught YK being affected by pollution
28. Competitive advantage	**13**	Unsure	Species not unique to Australia and is produced overseas. *Seriola quinqueradiata* known as yellowtail or Japanese amberjack is a competitor and so is Atlantic salmon (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).
29. Well marketed	**13**	Unsure	The export market to the USA is active and under development (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).
30. Fit the agribusiness chain	**13**	Yes	Its overseas success suggests a chain can be configured for Australian conditions
31. Suitable to environment	**13**	Yes	Native but not endemic to Australia (Smith *et al.*, 1993)
32. Not easily duplicated	**14**	No	Australia duplicate overseas aquaculture of yellowtail
33. Innovative/ marketed in a new form	**14**	Yes	Top grade sashimi fish
34. Government support	**14**	Yes	Unsure which organisation has supported this species
35. Improvement on existing product	**14**	Unsure	Probably not except for sashimi
36. Recovery rate/fillet yield	**14**	Yes	Last *et al.*, (1999)
37. Globally competitive/serve a global market	**14**	Yes	An internationally accepted fish which Australia should be able to produce in increasing volumes

Yellowtail kingfish should be flexible as it is successful overseas, but it needs more time to establish a track record in Australia.

Criterion 26 Serve a high value or high volume market

Yes.

This species can do both and is a top class producer of sashimi. (Yellowtail Kingfish Aquaculture in SA Fact Sheet www.pir.sa.gov.au; Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).

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30. Fit the agribusiness chain	**13**	Yes	Its overseas success suggests a chain can be configured for Australian conditions
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34. Government support	**14**	Yes	Unsure which organisation has supported this species
35. Improvement on existing product	**14**	Unsure	Probably not except for sashimi
36. Recovery rate/fillet yield	**14**	Yes	Last *et al.*, (1999)
37. Globally competitive/serve a global market	**14**	Yes	An internationally accepted fish which Australia should be able to produce in increasing volumes

Criterion	Rank	Yellowtail	Comment
38. Knowledge of species biology/ hatchery cycle	**14**	No	General lack of farming and scientific knowledge of the species but culture and biology can be related to aquaculture of yellowtail *(Seriola quinqueradiata)* in Japan (www.pir.sa.gov.au).

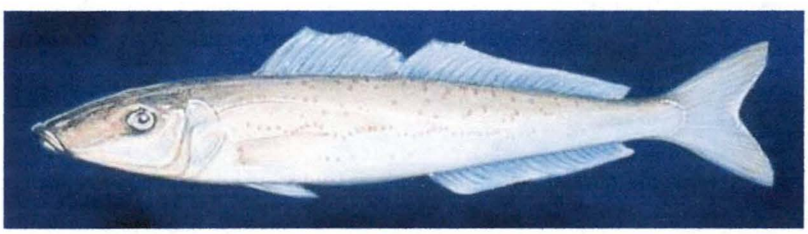
Table 6.12 Yellowtail noted criteria

Criterion	Rank	Yellowtail	Comment
39. Value	**15**	Unsure	Species size and yield should make it valuable for the increasing popular sashimi should
40. Fashionable	**15**	Yes	Sashimi should make this species increasingly fashionable
41. Similar species not grown overseas	**15**	No	The same and similar species are grown in Japan
42. Shortage of supply	**15**	No	More information needed
43. Adaptable to environment	**15**	Yes	Adapts very well to the aquaculture environment in South Australia (Yellowtail Kingfish Aquaculture in SA Fact Sheet www.pir.sa.gov.au)
44. Site availability	**15**	Yes	Sites are limited. (Yellowtail Kingfish Aquaculture in SA Fact Sheet www.pir.sa.gov.au).
45. Chemical free production	**15**	No	Insufficient information available for assessment
46. Able to achieve first mover advantage	**15**	No	Industry up and running overseas
47. Potential to become a mainstream fish	**15**	Yes	Already a mainstream fish overseas
48. Synergies with current operations	**15**	Yes	Snapper farmers were able to switch operations to yellowtail indicating a synergic operation
49. Possessing scales	**15**	Yes	Biologically a scaled fish (Last *et al.,*1999)
50. Live market appeal	**15**	Unsure	More information needed
51. Low mortality rate	**15**	Unsure	More information needed
52. Advantage of being produced in Australia	**15**	Yes	Australia has a very good clean and green image which arguably differentiates aquaculture in Australia from other parts of the world.
53. Achieve a regular price	**15**	Unsure	More information needed

Conclusion

Yellowtail kingfish like Atlantic salmon has a long history of culture overseas. Its marketability, adaptability to aquaculture and profitability is to a large extent proven overseas, but it has yet to prove these over time in Australia. It appears snapper farmers converted to yellowtail because either snapper grew too slowly and fetched a poor price or that yellowtail was apparently a better option, begging uptake using snapper infrastructure. As yellowtail is not unique to Australia, the challenge for yellowtail is the same as the challenge was for the benchmark species salmon, that is, to produce a fish of superior quality in comparison to the same species grown overseas. Tasmanian salmon are arguably the finest farmed salmon in the world, *to wit,* the premium price consistently fetched in Japan despite world wide difficulties in the industry. A major difference between salmon and yellowtail is that yellowtail is native but not endemic to Australia and salmon is an exotic. That yellowtail is successfully cultured overseas augurs well for its production success in Australia, but a major problem is the species sustainability in the domestic and export marketplace. Yellowtail may face either over production or lack of demand, but is currently enjoying an enhanced status with chefs in Sydney. Yellowtail's suitability for sashimi is a potential competitive advantage in a growing marketplace. The species rated positive against most of the highly important and important criteria but an element of doubt remains on the essential criteria. The market exists and the species be easily farmed but the danger is over production intersecting with insufficient demand.

6.4.3 King George whiting *(Sillaginodes punctata* Cuvier 1829).



Source: Ham and Hutchison (2002)

Distribution

King George whiting (KGW) is a Southern Ocean species and endemic to Australia. KGW are distributed from Port Jackson (Sydney) in New South Wales, along the southern coasts as far south as northern Tasmania and westwards to Jurien Bay in Western Australia. KGW inhabit shallow inter continental shelf waters, including bays and inlets. Location is driven by diet and young fish live near where the seagrasses *Zostera* and *Posidonia* species grow in sandy, muddy and broken bottoms within tidal estuaries, bays and creeks. Small juveniles favour water from 2m to 20m in depth and adults inhabit more exposed waters along coastal beaches over sand and weed and reefs in depths up to 200m. (Jones *et al.,* 1993b; FishBase www.fishbase.org; Last *et al.,* 1999).

Life history

King George whiting spawn in offshore waters from late summer to winter; May to July in Victoria and spawning peaks in mid April in South Australia and late February to early June in South Australia. KGW are serial batch spawners, but the number of spawnings in a season is unknown. Fecundity increases as the female fish grow from an average of 100,000 eggs at 34cm length to 800,000 at 45cm. Their eggs are buoyant and their larvae are planktonic. Larvae move inshore to sheltered areas and settle out of the plankton when 60-80 days old and 15mm long. Juveniles remain in protected water for 2-3 years. Older fish (25cm>) move to deeper water particularly during winter. The species attains maturity at 3-4 years old when males are between 27cm and 32cm long and females between 32cm and 36cm long. The sex ratio is even then but among older fish (>50cm) females are four times more numerous than males. Juvenile KGW feed on benthic amphipods and other crustaceans then the diet expands as they grow to include polychaete worms, molluscs and peanut worms. The fishery is probably fully exploited (Jones *et al.,* 1993b).

Aquaculture

"The main issues with (aquaculture of) King George whiting are achieving a regular supply of good quality eggs from broodstock, poor hatchery production and the slow growth rate of KGW throughout both the larval and growout periods. A very popular and expensive table fish KGW has these technical problems to overcome before it can be trialled." (Ham and Hutchinson, 2002) There is good support for KGW both as a potential aquaculture species and for re-stocking programmes.

Table 6.13 is the Master Model applied against King George whiting for assessment.

Table 6.13 King George whiting assessed against the Master Model

Criterion/attribute/success factor	Rank	King George whiting	Assessed as
1. Marketability	**1**	Yes	Essential criteria
2. Adaptability to aquaculture/ease of farming	**2**	Unsure	
3. Well priced/profitable	**3**	Unsure	Highly important criteria
4. Short growth cycle time	**4**	No	
5. Market and consumer knowledge of species	**5**	Yes	
6. Versatility of carcase use	**6**	Unsure	
7. Available technology	**6**	Yes	
8. Robust/environmentally tolerant	**7**	Unsure	
9. Availability	**7**	No	
10. Economically produced	**8**	Unsure	Important criteria
11. Good FCR	**9**	Unsure	
12. Easy to produce juveniles	**9**	No	
13. Disease and parasite resistant	**9**	Unsure	
14. Quality	**9**	Unsure	
15. Environmentally acceptable production	**10**	Yes	
16. Able to develop diet	**10**	Yes	
17. Attractive	**11**	Yes	
18. Shelf life	**11**	Yes	
19. Potential to value add	**11**	Unsure	
20, Serve an established or potential market	**12**	Yes	
21. Closed lifecycle	**12**	Yes	
22. Herbivorous	**12**	No	
23. Euryhaline	**12**	No	
24. Uniqueness	**12**	Yes	
25. Flexibility	**12**	Unsure	
26. Serve a high value or high volume market	**12**	Yes	
27. Customer safe perception	**13**	Yes	Relevant criteria
28. Competitive advantage	**13**	Yes	
29. Well marketed	**13**	Unsure	
30. Fit the agribusiness value chain	**13**	Unsure	
31. Suitable to environment	**13**	Yes	
32. Not easily duplicated	**14**	Yes	
33. Innovative/marketed in a new form	**14**	Unsure	
34. Government support	**14**	Yes	
35. Improvement on existing product	**14**	Unsure	
36. Recovery rate/fillet yield	**14**	Yes	
37. Globally competitive/serve a global market	**14**	No	
38. Knowledge of species biology/hatchery cycle	**14**	Yes	
39. Value	**15**	No	Noted criteria
40. Fashionable	**15**	Yes	
41. Similar species not grown overseas	**15**	Yes	
42. Shortage of supply	**15**	Yes	
43. Adaptable to environment	**15**	Yes	
44. Site availability	**15**	Yes	
45. Chemical free production	**15**	Unsure	
46. Able to achieve first mover advantage	**15**	Yes	
47. Potential to become a mainstream fish	**15**	Unsure	
48. Synergies with current operations	**15**	Unsure	
49. Possessing scales	**15**	Yes	
50. Live market appeal	**15**	Unsure	
51. Low mortality rate	**15**	Unsure	
52. Advantage of being produced in Australia	**15**	Yes	
53. Achieve a regular price	**15**	Unsure	

The Australian Fisheries Research and Development Corporation (FRDC) undertook a three year (May 1997-June 2000) research project in conjunction with South Australian Research and Development Institute (SARDI) at the South Australian Aquatic Science Centre (SAASC) titled; *"Spawning and larval rearing of King George whiting relevant to aquaculture and fisheries biology."* This was supplemented by a complementary 'Farmed Seafood Initiative' project through the South Australian Government. "Environmental parameters were assessed to develop commercially viable larval rearing and feeding protocols to optimise survival throughout all stages of hatchery culture. The research also investigated achieving captive spawning of high quality eggs during the natural season and out of season, growth rates and feed conversion rates achievable at different temperatures throughout the juvenile grow-out period (Ham and Hutchinson, 2002). The results of the present study place King George whiting in the category of a potential species (Stage 1).

Essential criteria

Criterion 1 Marketability

Yes.

KGW has a delicate, mild flavour, white flesh and fine texture, which keeps well after freezing. In South Australia it is the most valuable fish species fetching up $42/kilo for fillets in 2000 (Last *et al.,* 1999; Ham and Hutchinson, 2002). The market size fish is only around 200g which means five fingerlings, if they all survive produce only 1 kg of fish (Wayne Hutchinson, Senior Research Scientist, Coastal Finfish Aquaculture PIRSA-SARDI, 27 May, 2003 personal communication) There is concern about the sustainability of the KGW fishery in South Australia (Ham and Hutchinson, 2002). According to Ham and Hutchinson (2000) fish farmers are interested in the aquaculture of KGW because of its high value and opportunities in established and potential markets.

Criterion 2 Adaptability to aquaculture/ease of farming

Unsure.

The species has yet to be farmed.

Highly important criteria

Criterion 3 Well priced/profitable

Unsure.

Fillets of wild caught KGW fetch up to $42/kg and whole fish up to $21/kg, but these prices drop off during winter. (Jan Ham, Research Officer, Coastal Finfish Aquaculture, personal communication, 27 June 2003). On 26 Jun 03 in the Melbourne Fish Markets, KGW fetched a high of $14.00/kg, a low of $7.50 averaging at $10/kg with 29 x 30kg bins sold. According to its market history in Melbourne the price fluctuates considerably. (Melbourne Fish Markets www.chsmith.com.au).

Criterion 4 Short growth cycle time

No.

KGW commonly grows to 35-60cm, weighing 0.3-1.4kg in the wild sometimes reaching 28 cm in 2-3 years. The species grows well during the summer months of December to March (Jones *et al.,* 1993b; Last *et al.,* 1999). Under aquaculture conditions it is estimated to be able to achieve a market size of 30cm in 2-3 years, weighing between 200 and 250grams. As previously stated it takes at least five fish to complete a kilogram of KGW, making slow growth in aquaculture a particular problem (Jan Ham, Research Officer, Coastal Finfish Aquaculture, personal communications February 2002, May and 26 June 2003). Land-based trials revealed the species took two years to grow to market size. (Tom Hyde, Manager Finfish Nutrition, South Australia Aquaculture Management, 1 July 2003, personal communication).

Criterion 5 Market and consumer knowledge of species

Yes.

Very well known and easily identified species (Last *et al.,* 1999).

Criterion 6 Versatility of carcass use

Unsure.

Versatility is unlikely because of the species small size and demand for its fillets.

Criterion 7 Available technology

Yes.

Ham and Hutchinson (2002) provide a good technological base. It appears the technology will have to be developed in Australia.

Criterion 8 Robust/environmentally tolerant

Unsure.

Appears tolerant and robust (Jones *et al.,* 1993b).

Criterion 9 Availability

No

Supply from wild harvested KGW is seasonal with supply peaking in July-August and dropping off in summer (Jones *et al.,* 1993b). This coupled with a fluctuating price makes the species unattractive to restaurateurs who prefer a stable price and regular supply. Stable prices and regular supply (achieved by aquaculture) would enable markets building in other Australian states, particularly New South Wales and Victoria.

Criterion 10 Economically produced

Unsure.

As part of the Ham and Hutchinson (2002) study, a programme sponsored by the Australian Fisheries Research and Development Corporation (FRDC) Dr Wayne Hutchinson provided the following production cost structure in Table 6.14 Economics of producing King George whiting in aquaculture. On the basis of Hutchinson's model production cost of $13.50 is too high, but the model was created in the absence of any production data. A more realistic figure may be available should trials produce this data in the future. There is a further problem in that it can be assumed that KGW may never reach industrial levels of production thereby achieving economies of scale.

Table 6.14 Economics of producing King George whiting in aquaculture

Assumptions				
Production (tonnes)		100		
Months to grow		18		
Production cycle (years)		1.5		
Survival rate		90%		
Market size (g)		220		
			Production cycle costs	
Capital			$1,0000	% of costs
System $1,000/t		10		
System capital ($million)		1		
Land and services ($million)		0.5		
Capital cost ($million)		1.5		
Interest (%pa)		8%		
Interest ($1000 pa)		120		
Depreciation (%pa)		10%		
	Interest		180	13.34%
	Depreciation		225	16.68%
Labour				
FTE/tonne		20		
FTE's		5		
$1000/100 tonne pa		40		
	Labour		300	22.24%
Operating costs				
Power				
$1000/100 tonne pa		75		
	Power		113	8.34%
Maintenance (% capital pa)		5%		
	Maintenance		75	5.56%
Feed				
FRC		1.2		
Feed ($/kg)		1.7		
Feed (tonnes)		120		
	Feed		204	15.12%
Fingerlings				
Cost $/unit		0.5		
Number needed per kg		5.05		
Number needed pa (x1000)		505		
Cost $/kg production		2.53		
	Fingerlings		253	18.72%
Total production costs $		1,349.03		100%
Total production cost$/kg		13.49		

Source: Wayne Hutchinson, Senior Research Scientist, Coastal Finfish Aquaculture PIRSA-SARDI, May 2003.

Important criteria

Criterion 11 Good FCR

Unsure.

Generally, FCRs around 1 are acceptable. Optimum diets for KGW have not yet been developed. However, research indicates that KGW fed on commercial barramundi feed (Skretting Australia) can achieve FCRs around 1 during the nursery phase (Ham and Hutchinson, 2002)

Criterion 12 Easy to produce juveniles

No

Juveniles can be produced (Ham and Hutchinson, 2000) but KGW have problems with egg production and low fecundity. Larval survival is also a problem and research is underway into improved extruded pellets for broodstock nutrition. These are regarded as bottlenecks or stage gates to be overcome. (Jan Ham, Research Officer, Coastal Finfish Aquaculture, personal communications February 2002 and May 2003).

Criterion 13 Disease and parasite resistant

Unsure.

Under aquaculture conditions KGW may suffer from digenean (parasitic flatworms including liver blood and gut) flukes, parasitic *Cryptocaryon* irritations, bacteria *Vibrio alginolyticus* and *Pseudomonas aeruginosa* and the fungi *Exophiala salmonis* (Ham and Hutchinson, 2002).

Criterion 14 Quality

Unsure.

Wild KGW is well regarded as a good quality fish (Last *et al.,* 1999), but cannot as yet be compared with fish grown in aquaculture.

Criterion 15 Environmentally acceptable production

Yes.

This answer is an assumption based on respondents' attitudes to environmental issues during the present study. The view was that environmental regulations are adequate and new species production must meet standards already established.

Criterion 16 Able to develop diet

Yes.

Juveniles accept a commercially available off-the-shelf barramundi diet (Ham and Hutchinson, 2000).

It can be reasonably safely assumed that either a species specific diet may be developed or KGW can be fed on an existing feed formulation.

Criterion 17 Attractive

Yes.

"The flesh is white with find texture and mild flavour." (Last *et al.,* 1999).

Criterion 18 Shelf life

Yes.

Flesh keeps well after freezing (Ham and Hutchinson, 2000), so it is assumed to have a reasonable shelf life.

Criterion 19 Potential to value add

Unsure.

The demand for KGW fillets is so high that it may negate any value adding potential.

Criterion 20 Serve an established or potential market

Yes.

Market for wild harvested KGW is well established in Australia (Ham and Hutchinson, 2002).

Criterion 21 Closed lifecycle

Yes.

Problems remain with egg production and larval rearing (Jan Ham, Research Officer, Coastal Finfish Aquaculture, personal communication 26 June 2003).

Criterion 22 Herbivorous

No.

Juvenile KGW feed on benthic amphipods and other crustaceans. As the fish grow their diet expands to include polychaete worms, molluscs and peanut worms (Jones *et al.,* 1993b).

Criterion 23 Euryhaline

No

Criterion 24 Uniqueness

Yes.

KGW, the largest Australian whiting species from the family *Sillaginidae,* is endemic to Australia (Ham and Hutchinson, 2002)

Criterion 25 Flexibility

Unsure.

No estimate can yet be made on this, but because of size it is assumed aquaculture of KGW will be a narrow and highly specialised field.

Criterion 26 Serve a high value or high volume market

Yes. The market is high value

Relevant and Noted Criteria

Tables 6.15 and 6.16 list the Relevant and Noted criteria with appropriate comment

Table 6.15 KGW relevant criteria

Criterion	Rank	KGW	Comment
27. Customer safe perception	**13**	Yes	No reports are evident of pollution problems around potential sites, nor is there evidence of wild caught KGW being affected by pollution
28. Competitive advantage	**13**	Yes	KGW has the competitive advantage of being a premium fish native to Australia.
29. Well marketed	**13**	Unsure	Wild caught species sells itself. Larger numbers of KGW produced by aquaculture may require some marketing.
30. Fit the agribusiness value chain	**13**	Unsure	KGW should fit the chain, but this is yet to be seen. More knowledge is needed.
31. Suitable to environment	**13**	Yes	Yes. Unique to Australia
32. Not easily duplicated	**14**	Yes	Yes. Unique to Australia
33. Innovative/marketed in a new form	**14**	Unsure	Marketing seems currently OK
34. Government support	**14**	Yes	FRDC and the South Australian Farmed Seafood Initiative
35. Improvement on existing product	**14**	Unsure	Quality of the aquacultured species is yet to be seen
36. Recovery rate/fillet yield	**14**	Yes	See nested table below. Source: Ham and Hutchinson (2002)

Size class	Weight range (g)	Av. recovery rate (%)
Small	170-190	57
Medium	190-220	57
Medium large	220-230	57
Large	230-250	62
Extra large	300-340	62

Source: Ham and Hutchinson (2002)

Criterion	Rank	KGW	Comment
37. Globally competitive/serve a global market	**14**	No	Large scale production may be a problem
38. Knowledge of species biology/hatchery cycle	**14**	Yes	Ham and Hutchinson's (2002) study provides a solid base for future work

Table 6.16 KGW noted criteria

Criterion	Rank	KGW	Comment
39. Value	**15**	No	KGW caters for the upper end of the market and if successfully cultured will be a niche species.
40. Fashionable	**15**	Yes	Generally thought of (along with striped trumpeter (ST)) as one of the best three eating fish in Australia. KGW and ST's rarity makes them fashionable.
41. Similar species not grown overseas	**15**	Yes	Species is both native and endemic to Australia.
42. Shortage of supply	**15**	Yes	Wild catch is declining (Jones *et al.,* 1993b).
43. Adaptable to environment	**15**	Yes	Species is both native and endemic to Australia.
44. Site availability	**15**	Yes	Sites are assumed to be available
45. Chemical free production	**15**	Unsure	Insufficient information for assessment
46. Able to achieve first mover advantage	**15**	Yes	Being unique it could do so easily
47. Potential to become a mainstream fish	**15**	Unsure	Unlikely because of its size and potential grow out regime
48. Synergies with current operations	**15**	Unsure	More information needed but it would seem KGW's size and delicate structure require a different value chain structure from other species.
49. Possessing scales	**15**	Yes	Biologically a scaled fish (Last *et al.,*1999)
50. Live market appeal	**15**	Unsure	Insufficient information for assessment
51. Low mortality rate	**15**	Unsure	Insufficient information for assessment
52. Advantage of being produced in Australia	**15**	Yes	Australia has a very good clean and green image which arguably differentiates aquaculture in Australia from other parts of the world.
53. Achieve a regular price	**15**	Unsure	Possibly, but more information is needed

Conclusion

In assessing KGW against the model, the frequency of "unsure" scores indicates the species needs more research. The substantial and transparent body of work produced by Ham and Hutchinson (2002) is a sound base and KGW has three important factors working for it to generate further research. First, the species is unique to Australia, second market demand is strong and third the wild catch is not large and is decreasing, possibly because the species has difficulty surviving in the wild rather than fishing pressure. Jones *et al.,* (1993b) noted that adult KGW are subject to predation by sharks and juveniles are eaten by flathead, Australian salmon and barracouta. Obviously when grown in aquaculture there is not predation, but there may be cannibalism. Of all the assessment species KGW is in the earliest stage of research and development and would benefit from a further planned investigation using the stage gate approach of new product development. Ham and Hutchinson's (2002) work suffices for a desk top review to generate a "stop/go on" decision in the new product development process. Further investigation using this method could convert many of the "unsure" assessments to either "yes" or "no." This may also convert some of the "yes" and "no" answers to any of the three options. The benchmark species Atlantic salmon and barramundi, together with assessment species snapper and yellowtail kingfish, were not new aquaculture species, but new aquaculture species to Australia. KGW is both a new aquaculture species and a new aquaculture species to Australia. The results of the present study suggested that future new species may be either in the very early stages of investigation now or not yet under investigation. This small, delicate fish has a cultural identity in South Australia and is contained within an expanding culture of fish farming and an agribusiness system which may enable its development in the future. The tuna ranchers appear unlikely to switch species, but the snapper farmers have already switched to yellowtail kingfish and should yellowtail fail, King George whiting "on the shelf," with secure technology, waiting for uptake may be the ideal replacement species.

6.4.4 Striped trumpeter *(Latris lineata* Schneider 1801)

Source: Tasmanian Department of Primary Industries, Water and the Environment
http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/ALIR-4YA5F6?open

The species known in Australia also occurs in New Zealand and Chile (Battaglene and Morehead, 2000). Striped trumpeter inhabits the southern temperate waters of Australia (South Australia, Victoria, Tasmania and Southern New South Wales) and New Zealand (Last *et al.,* 1983 reviewed by Morehead, 1997), but is most abundant in Tasmanian waters (Roughley, 1961 reviewed by Morehead, 1997). Juveniles up to 2 kg are found inshore, whereas adults are found mostly on the offshore reefs at depths between 50 and 300 metres (Last *et al.,* 1983 reviewed by Morehead, 1997; Searle *et al.,* 1994), though it is most commonly found deeper than 120 metres (Last *et al.,* 1999).

Life history

The limited data available suggest that the spawning season for striped trumpeter in the waters around Tasmania is during September-October (Battaglene and Morehead, 2000). Striped trumpeter is demersal and feed on small fish and a variety of invertebrates, including octopus, squid, krill and other crustaceans (Hutchinson, 1994 reviewed in Morehead, 1997). Striped trumpeter reaches a length of 1.2 metres and a weight of 25 kg (Battaglene and Morehead, 2000), but commonly to 88cm and 7kg (Last *et al.,* 1999).

Table 6.17 is the Master Model applied against striped trumpeter for assessment.

Table 6.17 Striped trumpeter assessed against the Master Model

Criterion/attribute/success factor	Rank	Striped trumpeter	Assessed as
1. Marketability	1	Yes	Essential criteria
2. Adaptability to aquaculture/ease of farming	2	Yes	
3. Well priced/profitable	3	Unsure	Highly important criteria
4. Short growth cycle time	4	Unsure	
5. Market and consumer knowledge of species	5	Unsure	
6. Versatility of carcase use	6	Yes	
7. Available technology	6	Yes	
8. Robust/environmentally tolerant	7	Yes	
9. Availability	7	No	
10. Economically produced	8	Unsure	Important criteria
11. Good FCR	9	Unsure	
12. Easy to produce juveniles	9	No	
13. Disease and parasite resistant	9	No	
14. Quality	9	Yes	
15. Environmentally acceptable production	10	Yes	
16. Able to develop diet	10	Yes	
17. Attractive	11	Yes	
18. Shelf life	11	Unsure	
19. Potential to value add	11	Yes	
20, Serve an established or potential market	12	Yes	
21. Closed lifecycle	12	Yes/No	
22. Herbivorous	12	No	
23. Euryhaline	12	No	
24. Uniqueness	12	Yes	
25. Flexibility	12	Unsure	
26. Serve a high value or high volume market	12	Yes	
27. Customer safe perception	13	Yes	Relevant criteria
28. Competitive advantage	13	Yes	
29. Well marketed	13	No	
30. Fit the agribusiness value chain	13	Yes	
31. Suitable to environment	13	Yes	
32. Not easily duplicated	14	Yes	
33. Innovative/marketed in a new form	14	Yes	
34. Government support	14	Yes	
35. Improvement on existing product	14	Unsure	
36. Recovery rate/fillet yield	14	Yes	
37. Globally competitive/serve a global market	14	No	
38. Knowledge of species biology/hatchery cycle	14	No	
39. Value	15	Unsure	Noted criteria
40. Fashionable	15	Unsure	
41. Similar species not grown overseas	15	Yes	
42. Shortage of supply	15	Yes	
43. Adaptable to environment	15	Yes	
44. Site availability	15	Yes	
45. Chemical free production	15	No	
46. Able to achieve first mover advantage	15	Yes	
47. Potential to become a mainstream fish	15	No	
48. Synergies with current operations	15	Yes	
49. Possessing scales	15	Yes	
50. Live market appeal	15	Unsure	
51. Low mortality rate	15	Unsure	
52. Advantage of being produced in Australia	15	Yes	
53. Achieve a regular price	15	Unsure	

Aquaculture

Striped trumpeter is seen as an alternate and complementary species to salmon. Salmon faces increasing competition, risk of disease, cost of disease prevention and effects of climate change. Striped trumpeter is viewed as the best biological candidate for Tasmania and has a sound research base and structural resources available to overcome remaining problems (Morehead, 1997; Morehead *et al.,* 1999; Battaglene and Morehead, 2000). Striped trumpeter now has reliable captive broodstock which provide eggs all year round. It has a low stress response to handling but larval rearing remains the barrier to its development in aquaculture. Trumpeter's development needs greater commitment, especially from industry (Battaglene and Morehead, 2000). World wide, striped trumpeter is an unknown species. It has definite market potential but needs to be promoted with a value added image (Nick Ruello, Ruello and Associates, Seafood Consultants, 12 and 13 August 1999, personal communications).

Striped trumpeter was chosen as an aquaculture species because of its eating qualities, docile nature and presumed capacity to be farmed in high densities. (http://www.utas.edu.au/docs/tafi/TAFI_R&D_Sections/TAFI_R&D_Prog_Aqua_New_spp.htm) Existing Tasmanian aquaculture infrastructure would enable rapid uptake of research and development of striped trumpeter as a new species. The results assess trumpeter as a Stage 2 Trial Species.

Essential criteria

Criterion 1 Marketability

Yes.

Striped trumpeter, are "highly esteemed as one of the best eating fishes in Australia. The flesh is firm tasty and fatty," and is rated as one of the top three table fish in Australia (Searle *et al.,* 1994; Last *et al.,* (1999).

A strong, but limited market of 100 tonnes per year exists where striped trumpeter fetch ~AUD$ 18 per kg. (Battaglene and Morehead, 2000). A Tasmanian salmon company surveyed in 1998 expressed interest in growing striped trumpeter because of its limited world availability, aquaculture potential and long-term synergies with salmon in both farming and marketing. Japanese market research suggests trumpeter's white flesh is ideal for sashimi, a high value product. White flesh from trumpeter and pink flesh from salmon complement each other (Otton, 1998; Battaglene and Morehead, 2000).

The results of the present study revealed striped trumpeter contains larger amounts of Omega-3 polyunsaturated fat (a health benefit) than salmon and striped trumpeter was identified as a potential aquaculture species mainly on market criteria. In 1994, Searle *et al.,* (1994) estimated the Asian market could consume in excess of 1000 tonnes *per annum.*

Criterion 2 Adaptability to aquaculture/ease of farming

Yes.

Historical and contemporary evidence supports striped trumpeter's positive rating for this criterion.

"In 1882, the striped trumpeter was described as the most excellent of all Tasmanian fishes' (Royal Commission into the Fisheries of Tasmania). The Commission also reported that the striped trumpeter 'lives better and longer in a well than any other of our known fishes,' it 'will even feed in this confinement, and fish of this description have been kept alive over three months in the wells of boats.' There was also mention of the species being 'full of roe and milt.'" (Morehead, 1997). Searle *et al.,* (1994) noted than in 1994 the species had undergone four years of trials in cages at many different Tasmanian sites and appears to have a higher temperature tolerance than salmon, enabling growout in waters possibly not already utilised by salmon. The survey results also revealed that trumpeter domesticate very easily but its life cycle needs successful closure, and insufficient is known about the technicalities of producing a commercially saleable size fish.

Highly important criteria

Criterion 3 Well priced/profitable

Unsure

The species is yet to be grown commercially and no current price information was available from either the Sydney or Melbourne Fish Markets suggesting the species scarcity. However on 22 July 2003 price information was sought from two sources; Mures wholesale seafood at Hobart Docks and Kelleys seafood restaurant at Battery Point. Supply of striped trumpeter is spasmodic and trumpeter has a bag limit of 250kg per commercial fishing trip. Wholesale price was $23.90/kg for fillets on 20 Jul 03 but it can go to $25/kg. (Mures was supplied with 55 kg and Kelleys 12 kg on 22 July 2003). The price can go as low as $10/kg (and sometimes lower) depending on demand. Generally the price equals that of blue eye trevalla *(Hyperoglyphe antarctica* Carmichael 1818 and *Schedophilus labyrinthica* McAllister and Randall 1975) (Last *et al.,* 1999) (David Beresford, Mures Wholesale Seafood; Mike Kelley, Kelleys Seafood Restaurant, 22 July, personal communications).

Criterion 4 Short growth cycle time

Unsure.

According to Searle *et al.,* (1994), based on limited data, aquacultured trumpeter reaches 100 g in 12 months, 500 g in 24 months and 1.5kg after three years. Recent data supports Searle *et al.,* (1994) noting cultured juveniles reach 100g in one year, but wild juveniles reach 1 kg in a year (Battaglene and Morehead, 2000). Trumpeter's growth rate appears slower than salmon (Searle *et al.,* 1994). Until the lifecycle is successfully closed, its grow rate under aquaculture conditions cannot be assessed. (Dr Stephen Battaglene, School of Aquaculture, University of Tasmania at Launceston, personal communication, 27 June 2003).

Criterion 5 Market and consumer knowledge of species

Unsure.

Striped trumpeter is well known in Tasmania but would most likely fail a recognition test in other Australian states where it is seen irregularly in the fish markets and restaurants. The market is small and parochial because supply is limited. (Mike Kelley, Kelley's Seafood Restaurant, 22 July, personal communications). However, because a Tasmanian aquaculture company was originally involved in trumpeter's research and development, the Japanese market was investigated. The Japanese liked trumpeter and found the flesh most acceptable during March to August (Searle *et al.,* 1994).

Criterion 6 Versatility of carcass use

Yes.

Striped trumpeter has a high flesh recovery rate; lower than Atlantic salmon, but higher than most other marine finfish under development or in production (Searle *et al.,* 1994).

Criterion 7 Available technology

Yes.

The Australian State of Tasmania is well set up with technological infrastructure, intellectual property and corporate memory at the Tasmanian Aquaculture and Fisheries Institute (TAFI), several hatcheries and a strong aquaculture industry (Searle *et al.,* 1994).

Criterion 8 Robust/environmentally tolerant

Yes

Though technically not euryhaline, striped trumpeter have been caged in sites that experience periods of brackish water after high rainfall for periods up to four days in the upper two metres of a five metre (cage) water column. Striped trumpeter has also survived temperatures of 22° C in concrete raceways without problems. In the wild, trumpeter tolerates temperature from 8°C-22°C and salinities of 32-35ppt. This suggests suitability for sites around the State of Tasmania and optimum sites for fast growout in the Furneaux Island group to the North East of Tasmania (Searle *et al.,* 1994).

Criterion 9 Availability

No

Total catch is low and caught mainly between August and November. The Japanese market finds the fish unacceptable in taste, fattiness and oil content during the period September to February. Aquacultured trumpeter could even out this supply situation, catering for the Japanese market when the fish is most acceptable during March to August complementing the salmon harvest period (Searle *et al,* 1994). If striped trumpeter could be supplied consistently for a price around $17/kg for fillets, restaurateurs could build a market for the species. (Mike Kelley, Kelleys Seafood Restaurant, 22 July, personal communications).

Important criteria

Criterion 10 Economically produced

Unsure

The only financial modelling information is contained in the work of Searle *et al.,* (1994) which is now nearly ten years out-of-date. The authors note that though Tasmania has higher production and freight costs than competing states (and possibly nations), it has a state-based fish feed manufacturer and a local source of fish meal. They also identify efficiencies by integrating trumpeter production with current operations such as salmon (Searle *et al.,* 1994).

Criterion 11 Good FCR

Unsure.

No current data is available on striped trumpeter's FCR in captivity.

Criterion 12 Easy to produce juveniles

No.

Battaglene and Morehead (2000) reported that to maintain production of juveniles after trumpeter's lifecycle was closed, the species development required reliable capture broodstock and a year round, increased supply of good quality eggs. In the wild, it has been estimated that sexual maturity of striped trumpeter occurs at 5 years (1.3 kg) for females and 8 years (2.1 kg) for males. (Hutchinson, 1994 reviewed by Morehead *et al.,* 1999). It appears they spawn on the current, and, in doing so float half way to New Zealand, then swim back to Tasmania. Striped trumpeter's lifecycle was finally closed in the late 1990s (Morehead *et al.,* 1999; Battaglene and Morehead, 2000) and work is continuing to overcome problems of hatchery establishment (Battaglene and Morehead, 2000). Broodstock gathered from the wild are regularly spawned year round through temperature and photoperiod control. Larval rearing trials in 2001 and 2002 used naturally spawned and fertilised eggs instead of manually stripped eggs. Research at the TAFI Marine Research Laboratories in Hobart suggests that captive broodstock, fed a mix of commercial fish pellets (high in Vitamin C) and chopped fish (high in essential omega-3 fatty acids), provide eggs of comparable quality to those collected from their wild counter parts. Good quality striped trumpeter eggs should exhibit buoyancy, transparency, high fertilisation, very even cell division to the 16-cell stage and low drop out after hatching. Striped trumpeter has a complex and extended larval phase. Larvae are difficult to culture with a mortality peak occurring during the preflexion stage where larvae are 7-10mm long and 15-25 days old. Intensively cultured post-larvae or "paperfish" have a high incidence of jaw malformation and are susceptible to stress induced mortality. Dietary imbalances are in the three essential polyunsaturated fatty acids (DHA, EPA and ARA) in the live feeds are a potential cause of this mortality and malformation. Early larval survival has been improved with around with around 80%

survival to day 20 and up to 3.5% survival to day 100. Over 1200 three-month-old post larvae were produced 2002. Production improvements were achieved through a systematic approach to determining optimal rearing conditions, especially temperature and light and a better understanding of nutritional and feeding requirements. A pre-starter diet Gemma Micro has potential to nourish post-flexion larvae and has already proven successful with older fish.

The results of the present study indicated under shot jaw remains a major problem in the larval stages and this is supported by Batteglene and Morehead (2000). Research is ongoing to overcome this problem and other abnormalities in some fish due in part to *pentacapsular myxosporean polioencephalitis.* Research has established that the causative agent of this disease is a new species *Pentacapsula neurophilia.* (http://www.utas.edu.au/docs/tafi/TAFI_R&D_Sections/TAFI_R&D_Prog_Aqua_New_spp.htm).

Searle *et al.,* (1994) stated; "It is of vital importance that a large-scale, multi species marine fish hatchery is established in Tasmania, if this (striped trumpeter) and other species are to become viable culture options in the medium to long term."

Criterion 13 Disease and parasite resistant

No.

Potentially the scope is broad but two specific nervous system diseases have emerged as potential major bottlenecks; a nodavirus infection of larvae (currently confirmed from a single episode), and a more consistent myxosporean infection of somewhat older juveniles. Nodavirus identification is a major issue as the nodavirus affects striped trumpeter. Nodavirus damages the fish's brain, eyes and spinal cord (Anderson, 2001; East, 2001; Rimmer *et al.,* 2001). Searle *et al.,* (1994) listed *Flexibacter* and *Vibrio* species as common disease causing bacteria associated with severe stress or physical damage. With correct handling the condition disappears without the use of antibiotics. *Aeromonas salmonicida* has been identified in striped trumpeter broodstock and the same strain found in greenback flounder and Atlantic salmon.

Criterion 14 Quality

Yes.

Wild caught trumpeter is well regarded as a good quality fish (Last *et al.,* 1999), but cannot as yet be compared with fish grown in aquaculture.

Criterion 15 Environmentally acceptable production

Yes.

The results of the present study show striped trumpeter production is compatible with salmon production, though slower growing. The results also indicated that environmental regulations for salmon production in Tasmania are adequate. Farmed trumpeter would occupy sites currently or previously used to produce salmon and meet all the environmental criteria for salmon (Searle *et al.,* 1994).

Criterion 16 Able to develop diet

Yes

Trumpeter will eat the same diet as salmon but this is not optimal, particularly when conditioning trumpeter for spawning. Work is ongoing on larval and juvenile nutrition (Searle *et al.,* 1994).

Criterion 17 Attractive

Yes.

The survey results of the present study said the Japanese find striped trumpeter a visually attractive fish, an attribute very important for marketing in that country.

Criterion 18 Shelf life

Unsure

No information available

Criterion 19 Potential to value add

Yes

Trumpeter can be value added in same way as salmon in existing processing facilities (Searle *et al.,* 1994) and the species is suitable for sashimi (Otton, 1998).

Criterion 20 Serve an established or potential market

Yes.

The fishery serves a small market which may be restricted only because of limited availability of wild caught trumpeter. Market growth to consume expanding aquaculture production is an area for development should the species be successfully cultured. Trumpeter's equal in the marketplace is regarded as blue eye trevalla. (David Beresford, Mures Wholesale Seafood; Mike Kelley, Kelleys Seafood Restaurant, 22 July, personal communications). Trevalla's high rating is borne out by a Tasmanian aquaculture company doing a comparative study of blue eye and trumpeter aquaculture.

Criterion 21 Closed lifecycle

Yes/No

Literature previously cited confirms the lifecycle is closed but not yet successfully as problems remain with deformities (under shot jaw) and swim bladder problems.

Criterion 22 Herbivorous

No.

However, the results of the present study indicated that trumpeter may be herbivorous at some early stage of its lifecycle.

Criterion 23 Euryhaline

No.

Though technically not euryhaline striped trumpeter have been caged in sites that experience periods of brackish water after high rainfall for periods up to four days in the upper two metres of a five metre (cage) water column (Searle *et al.,* 1994).

Criterion 24 Uniqueness

Yes

Occurs almost exclusively in Tasmania and south east Australia (Last *et al.,* 1999).

Criterion 25 Flexibility

Unsure

In Australia striped trumpeter has production site options around the island State of Tasmania, in the Furneaux Group of islands to the North East and around the Victorian coast. It's assumed to be a satisfactory performer in the agribusiness value chain and has many marketing options (Searle *et al.,* 1994).

Criterion 26 Serve a high value or a high volume market

Yes.

The species is unlikely to serve a high volume market, but it can serve a high value market as white fleshed sashimi (Searle *et al.,* 1994).

Relevant and Noted Criteria

Tables 6.18 and 6.19 list the Relevant and Noted criteria

Table 6.18 Trumpeter relevant criteria

Criterion	Rank	Trumpeter	Comment
27. Customer safe perception	**13**	Yes	Tasmania has a reputation for being clean and green and aquaculture in Tasmania is either at, or close to world best practice
28. Competitive advantage	**13**	Yes	Almost unique to SE Australia, but could be produced in New Zealand
29. Well marketed	**13**	No	Market needs developing to cope with increased numbers should aquaculture be successful
30. Fit the agribusiness value chain	**13**	Yes	Should slot in well beside salmon
31. Suitable to environment	**13**	Yes	Research suggests that Tasmania may have the optimal climatic conditions for aquaculture of trumpeter
32. Not easily duplicated	**14**	Yes	Closed lifecycle of species will be valuable intellectual property
33. Innovative/marketed in a new form	**14**	Yes	Many value adding opportunities including sashimi
34. Government support	**14**	Yes	Aquafin CRC, TAFI, Tasmanian Government and FRDC
35. Improvement on existing product	**14**	Unsure	Should fill gaps in the white fleshed marine finfish market
36. Recovery rate/fillet yield	**14**	Yes	Not as good as salmon, but satisfactory
37. Globally competitive/serve a global market	**14**	No	Cannot serve a large market without huge production output which would mean displacing salmon in existing salmon sites
38. Knowledge of species biology/hatchery cycle	**14**	No	More work is needed on lifecycle closure and larval rearing

Table 6.19 Trumpeter noted criteria

Criterion	Rank	Trumpeter	Comment
39. Value	**15**	Unsure	Value needs establishing by marketing and promotion
40. Fashionable	**15**	Unsure	Generally thought of (King George whiting) as one of the best three eating fish in Australia. Trumpeter's and KGW rarity makes them fashionable. Trumpeter is not well known in some areas of Australia and could have its image enhanced by positive publicity
41. Similar species not grown overseas	**15**	Yes	Similar species are grown in Chile and New Zealand but their impact on any future striped trumpeter production is uncertain (Searle *et al.,* 1994). Other countries may have the same problems producing juveniles.
42. Shortage of supply	**15**	Yes	Wild catch is battling to reach 100 t a year This is a major reason for consumers' unfamiliarity
43. Adaptable to environment	**15**	Yes	Trumpeter has middle ranking temperature and salinity tolerance.

Criterion	Rank	Trumpeter	Comment
44. Site availability	**15**	Yes	Trumpeter is probably adaptable to any existing salmon site in Tasmania, plus the Furneaux Group to the North East. Sites need water at least 20m deep with good tidal exchange (Searle *et al.,* 1994).
45. Chemical free production	**15**	No	Producing any animal species either by agriculture or aquaculture without some chemical input is difficult.
46. Able to achieve first mover advantage	**15**	Yes	Australia could rapidly establish the species in a niche market and back it with increasing supply from production sites formerly used for salmon
47. Potential to become a mainstream fish	**15**	No	If successfully farmed, trumpeter should be a niche species as there is insufficient production capacity unless a major breakthrough that boosts production occurs
48. Synergies with current operations	**15**	Yes	Strong synergies with salmon (Otton,1998; Searle *et al.,*1994)
49. Possessing scales	**15**	Yes	Biologically a scaled fish (Last *et al.,*1999)
50. Live market appeal	**15**	Unsure	No information is available
51. Low mortality rate	**15**	Unsure	Insufficient information available
52. Advantage of being produced in Australia	**15**	Yes	New Zealand could become a producer of this species and Chile a producer of other related "trumpeter" species. Australia has a very good clean and green image which arguably differentiates aquaculture in Australia from other parts of the world, but this could be challenged by New Zealand
53. Achieve a regular price	**15**	Unsure	According to the Melbourne markets web site www.chsmith.com.au/ the price has varied greatly over the last six years.

Conclusion

The development of striped trumpeter is frustrating with around $AUD3 million invested in research and development and resolution into commercial production. (Professor Ned Pankhurst, July 2003, personal communication). Trumpeter was identified by both salmon and barramundi respondents' as a species poorly screened. When assessed against the master model, the obvious stage gate is production of juveniles, but information on other criteria is also lacking, indicating that more work needs doing on how the species will perform in the value chain. Nearly ten years ago Searle *et al.,* (1994) listed the following key commercialisation issues in sequence

1. Overcoming the propagation bottleneck

2. Determining the production economics of the species
3. Identification of viable growout systems and areas
4. Successful trial marketing of cultured product
5. Establishment of commercial scale hatchery systems
6. Implementation of a management plan and regulatory approvals
7. Refinement of nutrition, disease control and marketing techniques
8. Establishment of the first commercial scale production units

These and other issues are prioritised in Table 6.20 (by Searle *et al.,* 1994) which ranks value chain components and links in order of priority for further investigation.

Table 6.20 Ranked commercialisation issues for striped trumpeter

Value chain	Ranking
Broodstock management	1
Larval rearing	1
Site availability	1
Juvenile culture and nutrition	2
Feed formulation	2
Growth/performance	2
Assessment of demand for different product forms in key markets	2
Trial marketing of cultured product in export and domestic markets	2
Investigation of the disease *Aeromonas salmonicida* and its potential threat to salmonids	2
Investigation of available technology and commercial systems for live transport of fish	2
Development of hypothetical financial models for marine hatchery and growout phases	2
Commercial scale hatchery	3
Investigation of other significant diseases identified during production trials	3
Growout economics	3
Identification of competitive supplies of this species or similar	3
Development of financial models based upon growout and marketing trials to assess capital and cash flow requirements and potential profitability	3

The modelling results basically confirm the contemporary accuracy of Searle *et al's* (1994) work. These results confirm the need for a targeted new product development (NPD) process with focussed attention, and possibly help from overseas process applied to the species. The alternative is to abandon trumpeter as (currently) too difficult. Trumpeter has shown potential by passing several different screening procedures ahead of 'closed lifecycle' and remains a suitable candidate for development using a stage gate system as described by Cooper (1994; 1996). Using these processes means other sequences in striped trumpeter's development can continue as science overcomes problems with larval rearing (Battaglene and Morehead, 2000). Regrettably industry support was withdrawn from the striped trumpeter project in 2003 for reasons which most likely unrelated to trumpeter's aquaculture development. Morehead *et al.,* (1999) suggested future research and development should target desirable traits such as greater stress tolerance, faster growth and superior food conversion rates (Morehead *et al.,* 1999).

The work of Ross and Beveridge (1995), Williams and Primavera (2001), Le François *et al.,* (2002) and Quéméner *et al.,* (2002) is evidence of scientists examining new species options, with an expectation of finding a species that may be successful. Striped trumpeter in the Australian context keeps on coming up as a species which respondents either discard as having already used too many research and development resources with a limited success, or a species which has the potential to be a unique Australian aquaculture species and an aquaculture success story. If striped trumpeters' technology is secured, it has two further value chain problems; production capacity is limited (lack of sites, unless current salmon sites are used) and, though well known in Tasmania, a marketing campaign will be needed for the Australian domestic and export market.

Trumpeter is synergic with existing aquaculture infrastructure in Tasmania and the state has the basic requirement of cold water which is rarely available in Asian aquaculture countries like Thailand, Singapore or China. Striped trumpeter was viewed by some respondents as another biologist driven species. In the entire survey (given the doubt that exists about the species potential) striped trumpeter emerges as the best example of a 'product' which needs new a product development process applied to include all past, present and future work in a decisive stage gated relevant process to resolve its future as a potential aquaculture species.

Should striped trumpeter be successfully farmed, the marketing challenge is to build on its promotional advantage of being a very good eating white fleshed marine fish with the attributes to serve a larger domestic and niche export market as (possibly) sashimi. The catfish industry proved a broader market can be developed. Trumpeter has an arguable initial advantage in that it is already a high quality fish; therefore a targeted marketing programme starts with a better product, though not in the same abundant supply as catfish.

6.5 Discussion

6.5.1 Assessment species

Unlike Quéméner *et al.,* (2002) who started with a host of species, the species selected for assessment in the present study were chosen on two criteria. Each had attracted interest and investment and each had reached a point in their agribusiness value chain where an assessment (using the concept of agribusiness and the process of new product development) could be made of its likelihood of success. If success was elusive then the study indicated several possible courses of action; abandon the species, re-configure and rebalance the value chain or analyse how the new product process could have assisted the species development and how it may assist development of future potential candidate species.

The assessment species fall into three arbitrary stages of development extrapolated from the results of the present study:

Stage 1. Potential species:-King George whiting

Stage 2. Trial species:-Striped trumpeter

Stage 3. New species:-Yellowtail kingfish and snapper

Common threads were evident in these species assessments against the Master Model, but the major difference between the potential and trial species (KGW, trumpeter) and the new species (yellowtail, snapper) was that the lifecycle of trumpeter and KGW is yet to be closed (ranked 12) and juveniles are not yet easily produced (ranked 9) for trumpeter and KGW. "The global addition of new species to successful farming is very slow. There is the strong suspicion that much of this lack of progress results from the failure to establish reproductive control as an operational requirement early in the process of new species development." (Pankhurst 1998). The limited numbers of KGW and striped trumpeter in the wild may indicate problems at some stage of their lifecycles. Though their lifecycles are closed in the wild, an obvious problem is that both species may have trouble producing large numbers of juveniles in their natural environment. Snapper and yellowtail kingfish have the advantage of being successfully grown overseas and the challenge was adapting their technology to Australian conditions. Trumpeter and KGW are unique (ranked 12) and both have transparent, but limited data available.

Though the results of the present study indicated that trumpeter would benefit from a new product development process, this species and KGW show evidence of new product development processes. King George whiting's NPD process is much less advanced than striped trumpeter's. The question must be continually asked; "why develop any new species at all?" The problem with species like snapper and yellowtail is that they are available elsewhere. The only way Australia can benefit in the long term from yellowtail and snapper is to establish a competitive advantage which is difficult to replicate. However striped trumpeter is almost unique to south eastern Australia and KGW is unique to South Australia, and both are in short supply. There are common problem threads with the assessment species hinging (mainly) around profitability, their movement through the agribusiness value chain and their efficient presentation (in good order) to the best available market.

6.5.2 Agribusiness value chain

The next step in the process is to answer the question; "where does the present study take new aquaculture species development?" The results of the present study revealed that even with good research and development and the best intentions there is an element of "try and see" in the assessment process of new aquaculture species, because as a species matures in the agribusiness system, unexpected problems emerge. This has happened with the benchmark species which were all seen as successful at the time they were selected in 1999, although the species problems may have been embedded in the chain for some time. Each has immediate and looming issues which, at the time of establishment, were unforeseen or inconsequential, prompting a look back at the benchmarks to see the problems.

Atlantic salmon has become a generic fish, grown world wide and is now under sustained attack from the environmental movement. To remain viable in Tasmania the industry must either overcome rising water temperatures or be fortunate enough for this trend to conclude. To maintain a competitive advantage in a niche export market, and (currently) sound domestic market, the Tasmanian salmon industry must sustain its "clean and green" image. Catfish must overcome competition from cheap Viet Namese imports and consolidate the industry. This means rationalisation of operations at all stages of the agribusiness value chain. The industry has been cosseted for reasons other than pure commerce and may have to adopt a more realistic operational approach to retain critical mass. Barramundi, in addition to cost of production issues and lack of industry momentum problems, is in reality two species; freshwater and saltwater barramundi. Here is an example of where the new product development process can overcome a negative perception of *farmed barramundi* by developing products that eliminate this differentiation. The point is that, in applying the concept of agribusiness to the present study, a developer who takes the information herein is encouraged by the study to look "down the track" or "into the future" to endeavour to predict what internal and external forces may impact on value chain performance. No information was found on predicting a species performance (as a new product) in the product lifecycle.

The present study is differentiated from previous work because it endeavours to identify generic problems in new species development, what knowledge is needed when problems either arise, or are predicted, and what needs to be done. This produces a hierarchy of what needs to be known and when, described in the literature as the stage gate approach or system (Cooper 1994, 1996; http://prod-dev.com/stage-gate.shtml/). The Process Model assists in providing a structured explanation of data extrapolated from the Master Model by highlighting "sticking points" or "bottlenecks" in the process of assessing new species. The results of the present study indicated the usefulness of a "desk (or 'desk top') review" as described by Williams and Primavera (2001) that involves several steps to place a simple metric over an assessment species as a precursor to a more formal assessment. This review is a most important stage in new species development and is part of the Process Model. A "desk review" has limitations in that it may convince a company not to become involved in a new species at all or may strike out a species by concluding that the species does not warrant further investigation. An example here is striped trumpeter which under desk top review may meet both limitations. A stage gate process system is more compatible with the Master Model because in using it, a decision is made to go ahead with the species, abandon the species or defer judgement.
In striped trumpeter's case, the market for the species is strong therefore the opportunity (and challenge) is to manage the problem of closed lifecycle and juvenile supply by deciding at a stage gate whether or not it is feasible to proceed. This is a process by

which selection is undergone, providing minimum knowledge before the next stage, telling the developer what he needs to know and when.

Table 6.21 Process model

Stage	Knowledge	Decision		Action	
********************************		Yes	No	Example	Check success of same or similar species elsewhere and position in the product lifecycle. Assess attributes of uniqueness, attractiveness and flexibility.
Idea Source Idea generation	Species identity Business environment. Supply and demand	Screen the idea	Either abandon or put on hold for technological developments	Cobia Milkfish Big eye Trevally	
Idea screen (Desk top review)	Market?	Size and scope	Can a market be built?	Snapper Striped trumpeter Yellowtail Kingfish King George whiting	
	Ease of farming?	Assess cost of production and profit	Does a potential market justify further technical Evaluation		Assess how technical problems can be solved for example closed lifecycle. Assess species robustness, environmental tolerance and potential mortality rates
Scoping	Cost of production?	What is the financial and business risk?	Does the species have the merit to justify large research and development expenditure?	King George Whiting	Identify which market is to be served high value/high volume. Is the technology available? Identify and consult stakeholders Establish a cross functional development team.
	Government support	Investigate a contract or arrangement to source juveniles	Source non government funds or reconsider project	Striped trumpeter Snapper	
Second screen 2^{nd} Desk review	Does a preliminary economic model suggest species profitability?	Establish value chain function	Remodel the species on a revised value chain.	Snapper	Construct a virtual agribusiness value chain considering 1. Closed lifecycle and ease of producing juveniles 2. Disease resistance 3. Feed development 4. FCR 5 Growth cycle time 6. Quality and shelf life 7. Consumer knowledge of species 8. Versatility of carcass use, recovery rate and potential to value add
	Does production fit environmental models?	Proceed	Rework	Snapper	

Stage	Knowledge	Decision		Action	
*************************************		Yes	No	Example	Define and justify the market offering Make investment decisions Identify personnel to implement development
Build business case	Synergies with current operations?	Fit new species to current value chain and site	Establish alternate site availability Rework value chain to fit species and rework existing infrastructure.	Yellowtail kingfish	
	Can the value chain deliver the species to the target market?	Assess competition. Can quality and availability be maintained?	Production or marketing problem?	Snapper	
	Does the species have a sustainable competitive advantage?	Go to development	Consider abandoning the project	King George whiting	
Go to development	Do the reviews, consultations and modelling thus far indicate the species is worthy of development	Proceed	Reconsider project or seek another species	King George whiting	
Development	Implement the development plan.	Place species in grow out cages for assessment	Put species technology on the shelf for later uptake	King George whiting	Check production performance and monitor environmental compliance
Go to testing	Assess species In market place	Subtly put species to the market	Species already available as wild caught	Snapper	Where and how will the species be tested if at all?
Testing and validation	Commercialise product especially value added offering	Begin positioning the product and establishing outlets	Save for formal launch or ease on to market		Ensure sufficient supply to back early promotion
Go to launch	Venue, food and beverage support, co- launching with another product, print and electronic media coverage?	Advertise and go ahead with launch	Ease product onto the market quietly		Contact all stakeholders and invite to launch
Launch	How to assess launch impact.	*********************************			Ensure the new species message gets taken up by stakeholders
Commercialisation	Sustained agribusiness value chain performance	Stage 3 New species producing fish for sale. Observe supply and cold chain function. Monitor domestic market performance and assess export potential export		Yellowtail Kingfish	Assess how agribusiness value chain is working.

Because snapper and yellowtail kingfish have curriculum vitae elsewhere, business questions on those species can be answered, whereas they cannot be answered on striped trumpeter and King George whiting. In the early stages of new species development, aquaculture is yet to develop into agribusiness, as domestication of wild fish is the first of two different issues, domestication *and* the agribusiness of farming animals which though domesticated, may not adapt to farming.

Some outstanding questions (for which complete answers may only be available as a species proceeds along the pathway of development) arise from the Process Model.

1. Do the technical aspects appear soluble?

At best in many cases, it is an educated guess. For example the results of the present study indicated a feeling in the Australian aquaculture industry that the money spent on striped trumpeter's development was largely wasted. The counter argument is that the amount of money spent on this species (AUD$3.0 million) is indicative of how little was known and how much work needed to be done to establish a knowledge base for its aquaculture potential.

2. Can the nexus between science (technology) and business be overcome?

Yes, but currently there is a poor nexus between business and technology and neither science nor business has clear answers on what questions need to be asked. The critical stage for interaction between science and business is at the discovery or idea generation stage. Consolidation of research and development by centralisation will assist this process.

3. Is enough information available to make an investment decision in Australia?

No, and it is unlikely there will never be enough. For example a new species in Australia like yellowtail kingfish has much of the investment decision made for it. Because success eluded yellowtail's predecessor in South Australia, yellowtail as a 'switch' species was set in motion without (arguably) sufficient knowledge (or predictions) of its long term performance under Australian conditions. The same can be said of snapper for which the micro economic investment decision is continued availability of juveniles. But information is available which currently indicates these juveniles will not grow out quickly and may not fetch an adequate market price. The point is that this 'try-and-see' information is available now as the species matures in the agribusiness value chain *in Australia.*

4. What can be done to minimise risk?

There are so many variables that investment risk can only be minimised by using a deliberate planned approach to new species development. Once a species passes from a Stage 1 Potential species and becomes a Stage 2 Trial species it has to go in the water which doesn't necessarily increase risk but 'adds on' a list of potential events. Some results of the present study revealed that the greatest variable between fish farms is fish mortality. At Stage 4 Emerging species, Stage 5 Established species and Stage 6 Mature species, the temptation arises to switch species for many reasons. The ability and capacity to switch species may be an advantage of sea cage aquaculture because it reduces market acceptance risk of a species in the medium term, and concurrently farming an alternate species reduces short-term price fluctuation risk (Weston *et al.,* 2001). For example, PMA grow mulloway *(Argyrosomus japonicus* Temminck and Schlegel 1843) and snapper in the same area.

Any new product must have or gain market acceptance and its producer must configure to ensure a sustaining price in the market place. A big problem with new species is working out the cost of production. This is a mathematical calculation, but the real issue is delivering the product through the value chain where its competitive advantage is enhanced and value can be added in a variety of ways, even a simple brand name to convey a romantic or exotic image, for example Hiramasa Kingfish advertised in July 2003 at $25.90/kilo. Another example is in July 2003, the restaurant trade indicated concern over erratic supply of wild caught striped trumpeter, ranging in wholesale market price from $10/kg to $25/kg. The suggestion offered was the availability of consistent supply at a consistent price (suggested $17/kilo for fillets) so the trade could build a market.

6.6 Introduction to Chapter Seven General Discussion

The concluding chapter considers the validity of regarding aquaculture as agribusiness and the validity of considering new species as new products for the study. The conclusion further assesses how helpful these considerations were in generating a model and finally, what information does the modelling process provide.

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CHAPTER SEVEN
GENERAL DISCUSSION

He who returns from a journey is not the same as he who left.
A Chinese proverb

The concept of agribusiness and the process of new product development (NPD) were built into the structure of the present study via the compiled literature review. Chapter Three 'Methods' used agribusiness, NPD and the case study approach as described by Yin (1994), Sterns *et al.,* (1998) and Westgren and Zering (1998) to construct the research instrument, a qualitative questionnaire that elicited some quantitative responses. The method was applied to selection of benchmark species and their industries, the construction of the research instrument and its application. The method was continuously applied throughout the study as a whole, but particularly during interviews to analyse the operation of the benchmark industries and the participating companies within those industries.

Surveying two or three marine finfish aquaculture industries in Australia by asking; "why is your species (and industry) successful," would detail generic success factors, but lack insight into what generates success (a sound agribusiness system) and how this success can be determined for application to another species (an analytical process of NPD). The actual survey question; "why is catfish/salmon/barramundi aquaculture successful," was applied and provided the sixteen criteria in Table 4.24 (Benchmark species aggregate success factors), listed in Chapter Four, Results. The criteria and ranking produced by this simple process (resulting in Table 4.24) and the sophisticated process to determine criteria and ranking resulting in Table 6.4 Master Assessment Model, differed because the industry participants were responding in the first instance to a contemporary situation; "why is your industry successful?" In the second instance, respondents answered three questions in a virtual context where they could give an opinion on what should happen (if they had more control) rather than what has happened. These questions were:

"How would you specify the design of a new product?"

"What should be the selection criteria for a new species?"

"What attributes should an aquacultured fish have to survive and thrive in the marketplace?" The answers gleaned were aggregated with the answers from the question: "Why is catfish/salmon/barramundi aquaculture successful?" Responses to these produced fifty three criteria in the Master Model. The broader and deeper qualitative research used to construct the Master Model contributes to its validity as an assessment tool.

In all sectors of the industries surveyed, the results indicated that many players had not thought why their sector performed as it did; how it may perform in the future and how future options, for example, new products and new species might be assessed. This is where agribusiness and new product development proved invaluable. Overlaying the concept of agribusiness on the science of aquaculture alone would have resulted in an unnecessarily complicated work. Application of the new product development process disciplined the study. This prompts the question; "were the benchmarks a good choice?" The answer is "yes" because in the first instance all three were transparent with information relatively freely available. Although, at the time of survey, each sector had its own problems which, in some cases, restricted participants' willingness and ability to respond. All three evolved in the absence of an NPD process, but in the presence of adaptive business principles, an idea of the concept of agribusiness, and a process of scientific and market discovery which enriched their ability to act as benchmarks. In all cases a picture was built up over time, and in the case of salmon, this picture was enhanced by the translocation of the species world wide, thereby creating a global database of the species' performance in many production and marketing situations.
As expected, all three benchmarks conformed to the success factors identified in the Master Model with identifiable commonality across the industries.

Considering aquaculture as agribusiness for the present study was most useful in that it enabled a comprehensive analysis of characteristics of benchmark industry sectors. Collectively these three industry sectors provided a synthesis of the agribusiness and NPD nexus with the science of aquaculture.

To assist development a generic new species (development) process, several options exist. One is to have a national body which can be convened as required to examine ideas and proposals then provide direction on a course of action. The second is for governments not to offer any assistançe, and either let industry develop new species or have no new development at all. The third is to rely on importing technology for species that occur in areas as well as Australia and hope Australian competitive and comparative advantages will make the species profitable. The fourth option is for scientific research and development bodies to develop a group of species and place the completed technology on-the-shelf to await uptake. Finally the most obvious option is to keep the current system with the proviso that all future proposals must have a business case accompanying the scientific proposal. The business and science cases must include all relevant information from both disciplines together with structured new product development process stage gates, at which decisions are made to proceed, ask for more information or abandon the project.

Applying the new product development process to the present study was helpful because although aquacultured fish are (or have been) available as wild catch, the results revealed perceptions amongst survey respondents that positioned aquacultured fish from "different" to "new." The addition of an NPD literature review after the initial review work disciplined the study and provided a focussed direction for the complex science of aquaculture and the theory of agribusiness. Coincidently, the benchmark species Atlantic salmon was an excellent example of a genuinely new product in the Australian marketplace, giving Atlantic salmon a new product profile as an addition to its benchmark status. Product attributes to be considered when developing a new species as a new product were ranked variously on the Master Model. They are versatility of carcass use, pricing, availability, quality, product attractiveness, shelf life, potential for value adding, consumer safety, improvement on existing product, value, fashion and live market potential. The species itself and the agribusiness value chain are the mechanisms that deliver these. There is not yet the pressure on wild fish stocks to force a fish purchase decision based on scarcity.

Domestication of wild animals, an issue factored into the early planning work of the present study, emerged as a differentiator between aquaculture and terrestrial agriculture in the concept of agribusiness. According to Hughes *et al.,* (1992) domesticate means, "tame an animal to live with humans; accustom to home life and management; naturalise (plant or animal)." In aquaculture, the term appears to be used to describe a species that has its lifecycle closed, can be bred in captivity, and grown out to sale size by farming. This is valid, but an example exists with southern bluefin tuna in South

Australia, which as yet are technically not domesticated, but satisfy the criteria of 'adaptable to aquaculture/ability to be farmed.' Using the term domesticated makes new species development two issues, *domestication* and *farming*. Striped trumpeter has proven its ability to live in sea cages through growout trials, but cannot as yet be farmed because its lifecycle remains open in captivity.

New species development involves the domestication of wild animals whereas mainstream agribusiness is the ongoing production of domesticated flora and fauna adapted to farming with little recent addition of new species. This is an important difference because the results on several occasions revealed a view that future new aquaculture species may not yet be under consideration for aquaculture. Aquaculture has several areas of significant added complexity when compared to terrestrial agriculture. Farmed fish live in a variable and complex environment impacted upon by variations in temperature, salinity, dissolved oxygen and weather making them more susceptible to their physical environment than wild species and farmed land animals. A fish farmer's dependency on these systems is greater and more immediate than a land farmer is on terrestrial impoundments (Jauncey, 1996). A very important area of difference between aquaculture and agriculture (agribusiness) is market competition. The source of competition for aquacultured fish and the impact of wild caught fish on the market served by aquacultured fish need careful analysis. This is beyond the scope of the present study, but the industry must assess the strength of competition from other sources of protein, and the ability of wild caught fish to take a market segment, or cause the price of certain species to fluctuate on the random availability of wild harvested fish. In mainstream agribusiness, the source of competition is rarely wild caught product. For example, neither wild harvested poultry nor wild harvested swine are ever available in sufficient quantity or quality to offer competition to the farmed variety of both.

The above considerations and approaches gleaned data for the modelling from wider and deeper sources than would have been the case had only one or two of the three disciplines been used. Unsurprisingly the two most important criteria in selecting a new species are 'marketability' and 'adaptability to aquaculture.' It is possible to fit all fifty three criteria under those two headings, and a less in-depth study could have done so without identifying minor criteria, or some of the surprises that the Master Model delivered. Criteria 27 to 38 were ranked in order from 12 to 14 and therefore rated as 'relevant' criteria. Criteria 39 to 53 were all ranked at 15 and rated as 'noted' criteria. Amongst these criteria are several anomalies which merit further discussion. 'Site availability' is ranked at 15 together with 'synergies with current operations,' and this is somewhat surprising. A desk top survey conducted by industry players would immediately identify site availability as a most important criterion. The reason it did not rate highly, is probably because site availability is not an issue with new species development, it is an issue in the establishment of aquaculture. This cross-checked with the survey responses on the section devoted to the environment. The majority response was that aquaculture must meet all environmental requirements as prescribed by regulatory authorities. Once an area of water is gazetted as an aquaculture site, the opportunity for diversification into new species is available. For example, aquaculture of Atlantic cod is suited to most sites currently used in the northern hemisphere (and possibly some in the southern hemisphere) for aquaculture of Atlantic salmon. In Tasmania striped trumpeter is thought to be suited to all sites occupied by Atlantic salmon and possibly some not currently utilised, for example the Furneax Group of islands to the north east of the State. One of the times site availability would become an issue in new species development is when the there is no existing aquaculture activity or infrastructure in the region. Synergies with current operations should have rated higher and came up frequently in conversation, but infrequently as a direct response to a survey question, suggesting the participants rated the criterion as a given. Across the range of benchmarks, it is obvious that any new species would not be developed unless it fitted into the current agribusiness value chain. Striped trumpeter aquaculture is synergic with Atlantic salmon aquaculture, a huge advantage in analysing trumpeter as an alternate species (Searle *et al.,* 1994; Otton, 1998). But an exception would be, for example, reconfiguration of the chain by switching the production segment from ponds or cages to re-circulation. No recirculation producers were surveyed, but some respondents identified recirculation as the future because the production unit could be located close to major markets. The new species value must justify use of expensive land-based re-circulation systems to overcome site problems and be capable of supporting the investment. If successful, proximity to the market gives a new species venture, based on re-circulation technology, comparative and competitive advantages over pond, lake and sea-based fish farming systems unless they too are close to a market.

In view of current practices, 'herbivorous' and 'euryhaline,' both ranked at 12, probably occupied the correct places in the scoring hierarchy. The characteristic of eurythermous did not score at all. These characteristics if assembled, but not named, would probably go to make up the characteristics of 'robust/environmentally tolerant' ranked at 7, and assessed as highly important criteria.

Based on the concept of agribusiness and the process of new product development, the present study produced a definition of a new aquaculture species. *"A new aquaculture species is one not previously commercially cultivated or currently farmed, but with the potential to be successfully farmed and profitably marketed, surviving in the market place, either as a fish, or as derivatives and value-added derivatives from the fish."* This defines to the developer what the end result of the NPD process should achieve and the parameters for success. Information generated by the present study says that for success a new species must have a market, be adaptable to aquaculture and easy to farm. This is obvious, but the survey revealed many instances where species were selected as a result of a flawed decision making process and developed where the challenge became keeping the project afloat and keeping people interested. This simple initial market/ farming scan should highlight an obvious candidate which will generate a development momentum of its own. However, the assessment must be deeper and wider, because catfish, though now a successful benchmark was originally one of a suite of species and not the favoured candidate.

Drivers for development go deeper than declining catch. Looking at the benchmarks, Atlantic salmon is exotic to Australia and its technology was imported with the species. Catfish, native, but not endemic to the United States had its technology developed from scratch, and barramundi, also native but not endemic to Australia had its technology imported. Hence these three species (when new) were developed for similar reasons by differing methods, a feature not apparent when they were selected as benchmarks at the beginning of the study. Southern bluefin tuna, a species outside the scope of this study was probably ranched for reasons external to declining catch. Why throw a small fish back and incur the expense of re-capturing it when it can be caged and fed to enhance its market presentation? The driver to close tuna's lifecycle is therefore slightly disguised and, if successful, may change the current industry structure, making

SBT more available, less expensive and less profitable for the owners of wild quota who currently control the on-growing industry

Some of the answers to how the process of new species selection should work are found in the history of the benchmarks, where development of all three was driven by the impetus of converging factors. Catfish development resulted from deliberate United States government policy to develop a freshwater finfish for aquaculture in the South. In the South, development coincided with a decline in the value of terrestrial agriculture and in some cases a decline in soil fertility. Geographical assets of flat land; ground water and usable river systems (for transport) were available, overlaid by well developed infrastructure, a working agribusiness system, an evolving market and available research facilities. The Tasmanian government also deliberately selected salmon to capitalise on geographical assets, a developing infrastructure, research and development, and an electorate ready and willing for uptake of a new industry. Barramundi development is almost a cross between salmon and catfish development, though it was probably driven initially by farmers (with suitable assets of land and water) examining alternatives to agriculture or additions to existing operations. Amongst the benchmarks, shortage of supply was not necessarily a driver. Atlantic salmon had no commercial landings in Australia; catfish were still plentiful in America as are barramundi in Australia; however none of these species had reached a critical stage where their market presence depended on aquaculture. For example, in Australia in 2003, wild caught barramundi still actively competes with farmed barramundi.

The assessment tool says that a new species must not only fit "a market," it must fit "an agribusiness value chain" but most important the species must fit *"the situation."* All successful new species development in Australia is the result of the right situation to initiate and nurture the species development. The concern with striped trumpeter and King George whiting as new species for example is that although infrastructure exists for rapid uptake of these species, they are difficult to develop and a critical mass may not be achieved in subsequent industry. In 2003, predicting the likelihood of a new species being developed in Australia is difficult, but the modelling and assessment process provided a structured approach and analysis guide for doing so. Critical to new species success is the rate and extent that production and marketing knowledge diffuses to enable rapid uptake of the species. This in turn creates a visible and measurable expansion ratio.

In both terrestrial agriculture and aquaculture, it seems that for successful farming, creatures must either already occur in large numbers in the wild, or have done so in the past. This *Wille zum Leben* (will-to-life) as described Schoenhauer (de Botton, 2000), appears an inherited characteristic, often enhanced by favourable environmental conditions.

Having established that a potential species has a market and can be farmed, the next three steps are closing its lifecycle, assessing its profitability *under aquaculture conditions* and investigating the current scope of the market and the potential for market growth. Closing the lifecycle is vital, but has proven an obstacle or stage gate for some species where most of the remaining selection criteria are satisfied, for example, striped trumpeter. Not only must the lifecycle be closed but juveniles must be easy to produce and readily available. Profitability at this stage, according to the results from the present study is likely only a guide, but according to the results, short growth cycle time, versatility of carcase use, robustness, environmental tolerance, disease and parasite resistance, good FCR, ease of producing juveniles, diet development, potential to value-add and length of shelf life are some of the essential criteria for factoring into the economic model. Market dynamics need careful examination because even though demand exists for the selected species, the farmed version is a new product, and may be juxtaposed in the marketplace with its wild equivalent; for example farmed and wild barramundi. Because the new species and its derivatives are new products, market knowledge, consumer knowledge and consumer perception of the species need analysis. Contributing criteria to this process are attractiveness, availability, quality, environmentally acceptable production, customer-safe perception, and possibly uniqueness. The aquacultured species is the end product of a chain of events, some early segments of which are very different (i.e. farming) from those delivering a wild fish to market, but also some segments of the cold chain function in a similar way for both farmed and wild harvested fish. The farmed fish has a traceable chain which better suits a population increasingly concerned about how and where food is produced. This assists in satisfying the criteria of environmentally acceptable production, chemical-free production, and customer-safe perception as problem sources are readily identifiable. Also, if chain traceability is corrected designed and implemented, production can be located at a variety of different sites with a greater degree of confidence than may be currently enjoyed.

The study revealed that producers in all three benchmark industries were aware that many factors impact on the ongoing price of a new aquaculture species after it appears on the market (see Brown and Connell, 2001). Table 7.1 shows how catfish prices have varied over 15 years showing a price 61.7 cents per pound in 1987, peaking in 1995 at 78.5 cents per pound and tapering off in 2001. This fall in price was due to competition from imported Vietnamese catfish (see Jepson, 2000), coupled with domestic over production in the United States. A price of 76.4 cents/lb in1988 is less in real terms than 75.1 cents/lb in 2000. This shows that the initial price received for a new species tends to decrease and equalise as the industry producing it ages.

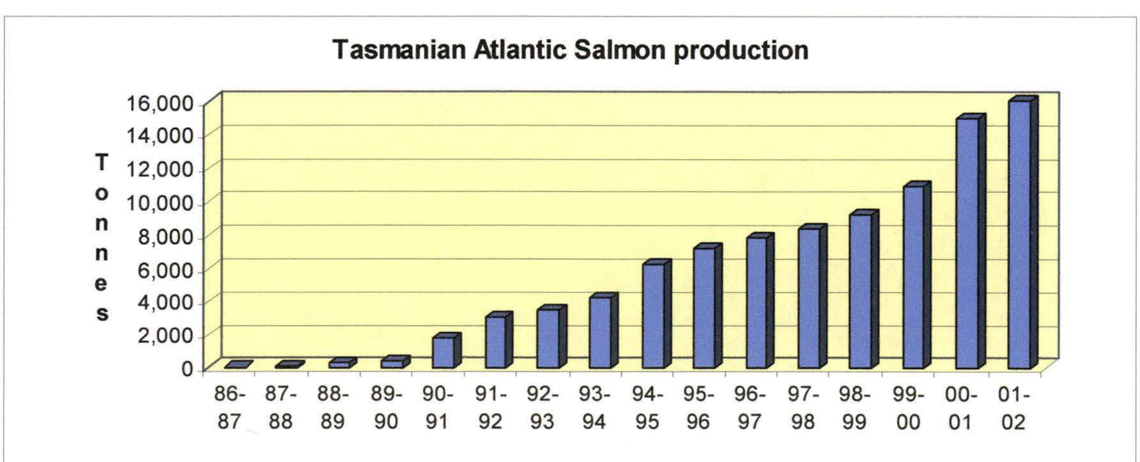
Table 7.1 Average price paid by processors for farm raised catfish

Year	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01
Cents/lb	61.7	76.4	71.5	75.8	63.1	59.8	70.9	78.4	78.6	77.3	71.2	74.3	73.7	75.1	64.7

Source: USDA data courtesy of the Mississippi State Department of Agriculture and Commerce (2003)

Framed Atlantic salmon grown in Tasmania appeared on the Australian market in 1986-1987 at around $15-$17/kilo (Nick Ruello, Ruello and Associates, personal communication 9 Feb 04). Figure 7.1 shows Tasmanian salmon production up till 2001-2002.

Figure 7.1 Tasmanian salmon production



Source: Tasmanian Salmonid Growers Association (2004)

In addition to the catfish example Table 7.2 indicates a similar process of price equalisation in farmed salmonids.

Table 7.2 Atlantic salmon and ocean trout farming in Tasmania

Years		95-96	96-97	97-98	98-99	99-00	00-01	01-02
Production HOGG	tonnes	7,647	7,647	7,485	8,993	10,907	12,724	14,292
Value	$'000	58,500	58,500	63,691	71,518	84,845	99,247	111,476
Unit value	$/kg	7.65	7.65	8.51	7.95	7.78	7.80	7.80

Source: Department of Primary Industries, Water and Environment (Tasmania) in Love and Langenkamp (2003)

A potential developer should be aware that the price initially received for a new species in the market is rarely sustainable because a variety of factors impacting on the agribusiness value chain will over time affect the products end price. The data revealed that as the benchmark industries aged the return per kilogram or per pound decreased in real terms.

Many of the criteria are initiators of discussion points, at which (in some cases) only predictions can be made. However, these points cover a wide range of areas that other studies do not. A euryhaline, eurythermous herbivore is hard to find, and when found may not be suited to aquaculture, but if one is found that passes all other criteria, then, from a farming aspect, it has distinct advantages. Early identification of a species' potential competitive advantage enables assessment of whether it has sufficient competitive advantage in either farming or marketing, or whether this characteristic can be built into the chain. This could be for example, the ability to have the species well marketed, because it is not easily duplicated or is innovative or marketable in a new form. Catfish, when under assessment, was probably seen to have potential in a high volume market, whereas Tasmanian salmon had potential in a high value market. These are important assessment criteria because in both cases, volume or value does not matter; it is the ability of the species to serve the market with a good product and make money. The ability of a new species to serve a global market may not be regarded as an initial selection criterion, but is part of a consideration of; "how far will this species go?" Its potential may not only recoup research and development expenses, but may eliminate the need for development of similar species which, when mixed together in smaller quantities, add up to the same market offering. Important new species development considerations are that Australian aquaculture cannot as yet satisfy a high volume global market, but domestically it can serve existing markets, supplement short falls in wild catch, build new markets and sell into a selection of high value markets at home and abroad. The future marine finfish mix is most likely to consist of several main species, for example, tuna, salmon, barramundi and possibly yellowtail kingfish. Several of these produce sashimi, a new product in Australia enjoying growing domestic demand and a large export market. The second tier of marine finfish may comprise the existing species snapper, and perhaps yellowtail kingfish (if it fails to reach high levels of production) plus the new species striped trumpeter and KGW. This mix should include warm water and temperate water species; suggesting development of species complementary to or suitable for polyculture with barramundi, and a selection from a suite of high value species which may include grouper, barramundi cod and coral trout. Barramundi is the only "national" fish because of its range of production options. Other marine finfish aquaculture is regional giving rise to a view that new species development will continue being regionally-based with cooperation and assistance from state and national bodies. There is no obvious species, new or otherwise, that that will exceed either salmon or tuna in production and value in Australia. In contrast, at national and international levels in the northern hemisphere, Atlantic cod aquaculture may overtake salmon, driven by salmon farmers seeking an alternate species to use salmon infrastructure rather than a species to compensate for a destroyed cod fishery.

Many of the lesser criteria identified in the present study do form the selection and development 'jigsaw' for consideration. Asking the question; "is supply really short, or can supply be filled by a similar wild caught species, or other source of protein including another aquacultured fish," is vital. A linked question is; "can this species improve on the existing product?" If it cannot, then the species, at this stage gate should be reconsidered or abandoned. Government support was very important to all the benchmarks, but new species development can proceed without it. Most significant, government support enabled hatchery set-up for both barramundi and salmon, and now several private hatcheries operate in the two sectors.

In the future, salmon will most likely metamorphose into a more streamlined, consolidated production and marketing entity, possibly repositioning its marketing campaign to represent Tasmanian salmon as even 'cleaner and greener' than currently emphasised. Given its infrastructure, the industry should grow more ocean trout, a species rising in popularity, and re-examine alternate species, the obvious choice being striped trumpeter. Finfish aquaculture will survive in Tasmania either as a consolidated salmon industry or (ideally) a broader industry with several species.

During the present study, concern was expressed (outside the parameters of the survey) about industry involvement in striped trumpeters' research and development, in that one aquaculture company, through its participation in the trumpeter project managed to partially tie up the species intellectual property. Whether or not this assertion is true only matters because another respondent opined that the role of government is to develop selected species and have the technology on-the-shelf for uptake by industry. The idea of restricted access to intellectual property may impede new species development, because, if several companies were given the technology, each would use it differently, some would succeed and others may fail. This suggests that research and development include a group of potential species with similar technology and similar infrastructure requirements.

The marketing issues, though beyond the scope of the thesis, emerged during the five years of thesis research process as significant in new species development and went some way to confirm Professor Pankhurst's hypotheses in Chapter One General Introduction. The present study provided new insights into new species development by conducting "real time" case studies into three diverse but successful aquaculture species thereby:

1. Creating a process that enabled a multidisciplinary analysis of a species potential using mainstream new product development and stage gates.
2. Disaggregating the agribusiness value chain and providing a virtual or model agribusiness value chain and a real agribusiness value chain showing chain components and links based on case studies of the three bench mark species.
3. Establishing a table (5.11) of amalgamated selection criteria and comparing these with mainstream industry selection criteria. Then, as the Master Model, applying it to the benchmark species and the assessment species.
4. Designing a process model (Table 6.21) to facilitate the selection process of a new species and gain an insight into its likely performance.

Currently in Australia, it seems there will be steady additions to the range of new species under consideration, but reflecting on past performances, very few should proceed beyond idea stage and the chances of successful new species selection and development rests on assessment against a structured process like the one developed in this study.

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APPENDIX ONE

RESEARCH INSTRUMENT

David Otton
Telephone: 02 64
E mail: benooka@

Dear

I am writing to request your participation in a qualitative survey of the catfish/salmon/barramundi industry. I have a Masters' degree in agribusiness from Monash University and am studying full time for a Doctorate of Philosophy in Aquaculture at the University of Tasmania, Launceston. My PhD is fully funded by a Co-operative Research Centre (CRC) for Aquaculture Scholarship and partially funded by an International Food and Agribusiness Management Association Scholarship. My principal supervisor is Professor Ned Pankhurst, Head, School of Aquaculture and my co-supervisor is Doctor Lawrie Dooley, Agribusiness Programmes Manager, Monash University.

I come from a farming background with managerial experience (and ownership) in horticulture (peas and beans), grazing (Hereford cattle) and aquaculture (Sydney rock oysters).

The focus of my PhD is to apply the concept of agribusiness to the science of aquaculture. My project is to *establish an agribusiness model for assessing the commercial viability of new species for aquaculture.* Its themes are new product screening, new product development, industrialisation of agriculture (aquaculture) plus agribusiness value and supply chains. To construct the model I must establish selection criteria (by using mainstream business methods) for successful aquaculture species, and enabling criteria for their sustained performance in the agribusiness value chain. These criteria may be the same, but examples exist where potential aquaculture species have passed screening for development and commercialisation then failed when exposed to the reality of market forces. I am, therefore, case studying the following successful performers in aquaculture which, with their industries, are my benchmarks.

Catfish *(Ictalurus punctatus)*

Catfish, a regionally established freshwater species in the United States South, is the master template for sustained performance in the agribusiness value chain.

Atlantic salmon *(Salmo salar)*

Atlantic salmon is the globally established marine-farmed finfish, achieving industrialisation within a decade of commercialisation in Tasmania. Exotic to Australia, salmon form a model for closed life cycle finfish aquaculture and the master model for new species development.

Barramundi *(Lates calcarifer)*

Salmon grow in sea cages and catfish grow in fresh water ponds, whereas the euryhaline barramundi grow in marine and fresh water, enabling production in both environments using cages, ponds, tanks, or combinations of all three. These options enable widely dispersed, and less geographically confined production in mainland

Australia than either catfish in America, or salmon in Tasmania. Barramundi has the potential for industrialisation and the industry, for this project, in both production and marketing, serves as a link between salmon and catfish. It could develop into an industry in Australia similar to catfish in the United States.

The success and enabling criteria from the benchmark species, their industries, plus data from other successful aquaculture species, will be analysed and synthesised to construct the model. The completed model, after external validation against successful species, probably gilthead seabream *(Sparus auratus),* common seabream *(Pagrus pagrus)* and European seabass *(Dicentrarchus labrax)* will be applied to the project's first target species, snapper, then to the second and third species, striped trumpeter and greenback flounder. The model should indicate these species' suitability for long term aquaculture and have general application to potential new candidates across the range of marine, brackish and freshwater fish species.

At your convenience, I would like to ask you the attached list of questions in a face to face interview which, with your permission, I will record. The questions, drawn from my literature review are designed to be either answered directly or "talked around." I no longer have a commercial interest in aquaculture and will neither ask you for financial details, nor intentionally ask you any question that may be regarded as commercial-in-confidence. My supervisors and I have been through the questions several times.

The Co-operative Research Centre for Aquaculture Confidentiality Agreement covers my project therefore neither you, nor your company will ever be identified.

I live in New South Wales and if you are available, I will organise my visit to fit in with your schedule, if not I shall re arrange my visit to fit in with you.
Yours faithfully David Otton

Survey questions

New product ideas

1. How do you define a new aquaculture species?
2. Where do ideas come from for new aquaculture species and their products?
3. Where would you get ideas for new species and new products?
4. How would you appraise those ideas for new species?
5. What sort of organisation is likely to develop a new species?
6. Is your organisation structured to develop a new species?
7. Is your organisation currently investigating a new species?
8. How would you specify the design of a new product: what does a new product or species have to do?
9. How do you see the role of a product champion in developing a new product?

9a. How do you see the role of industry leaders in developing new species?

New product screening

10. What should be the selection criteria for a new species?
11. Do you think these criteria are generally applied?
12. Do you know of potential new species being poorly screened and subsequently developed without proper assessment?
13. Should fish farmers examine the possibilities for new species as ongoing business research, or expand production of already established species?
14. What attributes should an aquacultured fish have to survive and thrive in the marketplace be it domestic or export?

New product marketing

15. Where is your market?
16. Did you have to establish a market or was it already established with either wild harvested or other aquacultured species?
17. How do consumers' perceive your product?
18. Where is your competition and can your market grow?
19. To what extent does the market drive new aquaculture species development?
20. In new species development, how does the developer balance market demand for size, quality and continuity of supply against the realities of production?
21. How should the aquaculture industry innovate?

New product processes

22. Do you have a formal process for new product development?
23. How should the developer of new aquaculture products involve future potential customers in NPD?
24. When should representatives from all company functions (research and development, production and marketing) become involved in the NPD process?
25. How important is the new aquaculture product launch into the marketplace?
26. How does new species development feature in the future of aquaculture?

New product development agribusiness value chain

27. Why is catfish/salmon/barramundi aquaculture successful?
28. Was a new product development process applied to catfish/salmon/barramundi?

29. The value chain is a series of stages or events from selecting a species for culture, to marketing that species: What are the critical components of the catfish/ salmon/ barramundi value chain and how are these linked?
30. Could another species achieve catfish/salmon/ barramundi's success?
31. How important are strategic alliances in new product development?
32. How big are the issues of site availability, water value and use for new species development?
33. If you were to develop a new species, would you use the same strategy used to develop catfish/salmon/ barramundi?
34. How important were governments in establishing the catfish/ salmon/ barramundi industry?

Environment

35. When establishing, how did the catfish/ salmon/ barramundi industry cope with environmental issues?
36. How would you now develop a new species taking into consideration contemporary environmental issues?

APPENDIX TWO

CATFISH RESULTS

The fish is last to know if it swims in water

A Chinese proverb

Introduction

The survey, conducted by telephone during the months of October and November, 2001 elicited responses from four catfish industry players and one player outside the industry. The catfish players are two processors, one vertically integrated farmer and one agribusinessman who owns a catfish farm, operations within the catfish value chain and has agribusiness interests external to the chain. The telephone interviews lasted between one and one and one half-hours. One catfish participant responded in writing.
The external participant was interviewed (and resulting data included) because of his aquaculture knowledge, experience in new species development, association with catfish and company location near the catfish industry. Also his first new species operation was the subject of a case study within the Monash University Master of Business (Agribusiness) curriculum. Results follow the questions in numerical order and the responses are rated and summarised under abbreviations of the questions. Where relevant, response frequency is recorded immediately after the questions followed by brief explanations based entirely on the respondents' words. In some cases, respondents provided several answers for example five respondents gave eight answers to the question, "How would you appraise those ideas (for new species)?" Answer: Established market (5), Fish can be farmed (3). Where possible responses are rated in order of importance.

New product ideas

1. How do you define a new aquaculture species?

1. Any animal that swims, in either fresh or seawater that can be farmed and brought to market. Anything from clams to fish.

2. A new product is taking the basic raw material, farm-raised catfish, and marketing it in a new form. For example, a fully cooked, pre-seasoned, ready-to-warm-and-serve catfish entree in microwavable packaging would be a new product.

3. A fish other than catfish which can grow under the same conditions, for example grass carp *(Ctenopharyngodon idellus* Valenciennes 1844).

4. Any species that is not under aquaculture today.

5. A wild fish species that can be *successfully* farmed. Hybrid striped bass (striped sea bass *(Morone saxatilis* Walbaum 1792) X white bass *(Morone chrysops* Rafinesque 1820), channel catfish *(Ictalurus punctatus* Rafinesque 1818) and salmon *(Salmo salar* Linnaeus 1758) will not be successful species long term.

Summary

Definition of a new species

Catfish was once a new species and respondents identified a new species as one not currently farmed, but with the potential to be *successfully* farmed and profitably marketed, either as a fish, or as derivatives (value added) from the fish. For example, a new species may be grass carp *(Ctenopharyngodon idellus* Valenciennes 1844) and a new product fully cooked, pre-seasoned, ready-to-warm-and-serve catfish entree in microwaveable packaging.

2. Where do ideas come from for new aquaculture species and their products?

1. From universities like Auburn and Texas A and M. (Agricultural and Mechanical) researching a number of potential species until they find one that converts feed well and can survive in varying conditions, just like catfish. Thirty years ago Auburn University, funded by a government grant was trying to find a perfect freshwater fish to be developed and raised in North America under aquaculture conditions. *Auburn had no idea it would be a channel catfish.* The researchers thought it would be a sunfish, a bass or a trout, but after testing those fresh water fish, the channel catfish was the fish that which passed the selection criteria of good feed conversion and hardiness. Auburn then started promoting catfish to grain companies like Goldkist and Conagra to develop grain based feed. The companies then promoted catfish to farmers. These events started the industry.

2. Auburn University (Alabama) in the early 1960s experimented with raising channel catfish from a U.S. government grant geared toward supporting President John F. Kennedy's Peace Corps. Auburn University established the first aquaculture curriculum in support of this program. The University developed the early expertise in raising channel catfish in pond culture. Their practical experience in fish food development and nutrition, water quality, oxygen deprivation, and pond construction was available to any interested parties. By the late 1960s entrepreneurs were trying, on a small scale, to raise catfish in ponds, and market the live fish.

3. A species already known and eaten by consumers which can be grown under aquaculture conditions to offset the seasonality of wild species and achieve greater freshness.

4. Don't know, but too much money is being wasted on pet (new species) projects and not enough being spent on already successful species.

5. Market place.

Summary

Origins of general ideas for new species and products

Universities (2), Marketplace (2), don't know (1).

Ideas for new species came from research institutions studying a suite of potential candidates for experimental trials. An underlying theme of this project is to determine what initiates the new species agribusiness value chain. The catfish chain began with a United States Government grant to Auburn University, Alabama, geared toward supporting President J.F Kennedy's Peace Corps in the early 1960s. Auburn's task was to identify a "perfect" freshwater fish to be grown under aquaculture conditions in North America. According to the data, researchers had open minds with catfish, sunfish, bass and trout as contenders for a "desk top" review. Catfish unexpectedly emerged as the species that satisfied the agribusiness value chain selection criterion for hardiness and good feed conversion ratio.

Having selected and tried the successful candidate, Auburn set up an enabling environment of production technology, available to potential participants and supported by an education and extension programme. Recognising feed as a major variable (about 50% of production costs) Auburn liased with and promoted catfish to grain companies like Goldkist and Conagra, which took up nutrition solutions with farmers who held the necessary chain initiation assets of land with a ground water supply. Catfish's wide recognition and acceptance in the South, where about 25% of the United States population lives greatly assisted the convergence of factors leading to its development.

3. Where would you get ideas for new species and new products?

1. In one of two ways, by assessing which species will grow the best in an already available environment or a species that can be easily cultured then find an environment for it. In the southern part Australia in a climate similar to Mississippi (MS) it may be catfish. In the northern United States, probably walleye pike (*Stizostedion vitreun* Mitchill, 1818) or pickerel (*Esox spp.*) because catfish would not grow in that cooler water. First decide where to locate production aquaculture then figure out what species would grow the best in that environment.

2. A species which exhibited production and marketing synergies with catfish.

3. A known fish which could be researched for potential commercialisation.

4. Visit the fish market and observe what the public is buying.

5. Go to the market place and figure out what people are already eating and figure out how to produce that cheaper, better than anybody else. The idea for tilapia came from Toronto which has the highest fish consumption per capita in North America where observation of consumption choices and patterns gave a snapshot of the future. Three years prior to this visit interviews with wholesalers and brokers indicated that only 10,000 pounds or one truck load of live fish was being sold in the city per month and easily in excess of 90%-95% of their sales dollars were in fresh and frozen seafood. About 5% of sales were live seafood. Three years later the sales dollars were the same, but the live category had tripled the pounds of seafood sold. The live seafood was live tilapia, a high quality, inexpensive seafood, selling 70,000 to 80,000 pounds in quantity equating to seven or eight truckloads in Toronto every week with live seafood. Twelve to thirteen species of live high priced seafood, including catfish were carried in supermarkets and restaurants. Multiple sized and coloured cheap tilapias were loss leader fish that enticed people into the stores and live seafood departments was live tilapia. For every pound of something else they sold whether it is grass carp or large mouthed bass, striped bass or live shrimp, tilapia outsold everything else by a factor of ten. The in-store and restaurant investment to support sale of live fish indicated people no longer trusted the word fresh or frozen. People interpreted the word frozen as a means of disguising a rotten fish or it had died and it would smell if thawed. People didn't trust fresh because it may have been frozen and recently thawed, including the term "refreshed" suggesting the fish was once rotten and now disguised. The consumer had out smarted the marketing people and had decided for themselves; "I know the difference between live and dead! Live is swimming in a tank and dead is still." When the company switched species from hsb to tilapia it was not entering the tilapia business, it entered the *live tilapia* business. It costs 40 cents per pound to produce tilapia and it sells for $1.05 per pound.

The idea for hybrid striped (hsb) bass came in 1987-1988. Bass had public recognition. It looks like a fish and doesn't have whiskers like a catfish, or look ugly like orange roughy. It comes from Chesapeake Bay and in the mid 1850's, was transplanted to San Francisco Bay and therefore known on both coasts. Immediately recognised by consumers, demand was strong and it brought a high price. The hybrid was the catalyst, crossing the saltwater, ardromous fish, striped bass with a freshwater white bass, thereby producing a fish that could spawn and live inland. Lakes and dams were stocked it became known as a fighting game fish in the centre of America and known as a commercially caught fish on both coasts. *The marketing was already done and all the company had to do was supply it.* Commercial over fishing reduced supply while the demand was still there. After developing hsb the company achieved a top price of $4.55 per pound but settled to $2.50 a pound whilst costing $2.50 a pound to grow which made it unprofitable.

Summary

Sources of individual ideas for new species and products

Marketplace (2), Easily cultured fish (1), Known fish (1), Synergies with catfish. (1).

The data indicated previous, current and future interest in developing new species. The marketplace features as a prominent area for players to seek ideas for new species, qualified by how a new species would fit in the geographical and operating environment and what production and marketing synergies it has with catfish. Aquaculture must, by enhancement, lower the cost of production, improve quality, availability and value to customers of existing, popular wild caught species and deliver them in new forms.

4. How would you appraise ideas for new species?

1. The fish should convert feed well and survive in varying conditions.

2. A fish which could be delivered to a receptive market using existing channels and marketing infrastructure.

3. The fish can be grown under aquaculture conditions to overcome the marketing problems with wild fish of cost, freshness and seasonality.

4. Pick the species on the top end of the price range then think through the question and process of "could they be farmed?" Look for key characteristics, eliminating carnivorous species. For example pompano, a fine tasting, expensive, but carnivorous marine fish, fails a simple review because little is known of it.

5. There must be an established market. To acquaint the consumer with a new product is expensive. With tilapia the company entered a growing market showing future potential with live fish.

Summary

Appraisal of ideas for new species

Established market (5), Fish can be farmed (3)

Because of high research, development and establishment costs in new species commercialisation, including acquainting consumers with new products, the developer (in appraising new ideas) should reverse the value chain, working back from an established, high value market to the early stages of production. This determines the (potential) profitability of a candidate species by analysing its (potential) chain performance. A good target fish shows chain competitive and comparative advantage of good feed conversion, robustness, able to be delivered to a receptive market, overcoming wild caught fish marketing problems of cost, freshness and seasonality. The emerging, expanding market for live fish in North America makes a quantum step into the future as consumers no longer trust the terms fresh or frozen, increasingly seeing "fresh" as live fish, swimming and "not fresh" as dead fish, still. New products frequently enjoy success when entering expanding markets.

5. What sort of organisation is likely to develop a new species?

1. Companies that understand what the market wants, can link up with research institutions to determine which fish would do well, then take up the research, develop the both the species and a market for it. No company should attempt to develop a new species without close co-operation from an institution dedicated to research.

2. An existing company provided the species is a goer.

3. Farmers with suitable land for ponds, that is clay based soils and a good water supply. The research must come from universities.

4. A group of entrepreneurs who think they know something about fish. The major corporations (the Con Agras, Cargills and Swifts) have abandoned aquaculture and given up on the fish business.

5. A small entrepreneurial one, that has to fight for its existence every day.
It's like the "dot com" environment without the "dot com" label. The idea has to be pushed to the limit, constantly adapting, changing and modifying it to whatever the firm's next sale can be.

Summary

Organisations likely to develop a new species

Existing companies (2), Entrepreneurs (2), Farmers (1), Collaborative effort (1).

An entrepreneurial company or a group of entrepreneurs are organisations likely to develop a new species in addition to farmers with the primary resources of land and water as well as existing aquaculture companies. A developer company must understand market demand, develop alliances with research institutions to screen the new species, and have the capacity to take up the research, develop the species and its market. No company should attempt to develop a new species without close co-operation from an institution dedicated to research. Large agribusiness corporations, for example Con Agra, Cargill and Swifts no longer have an interest investing in fish farming. Existing aquaculture companies have the infrastructure and in skills to establish alliances with well funded institutions and marketing organisations to commercialise their work.

6. Is your organisation structured to develop a new species?

1. No. It has all the in house skills but needs would need an alliance with a well funded research institution and marketing organisation to develop a new species.

2. No. But it has the infrastructure and skill to market a new species developed by another organisation.

3. No. Not large enough to have a research department.

4. No.

5. Yes, achieved with tilapia. Then a live haul method called "the tote octopus" method to transport live fish.

Summary

Organisation structured to develop a new species

No (4), Yes (1)

Four of the catfish companies are not structured to develop a new species. The external company developed both hybrid striped bass and tilapia as new species.

7. Is your organisation currently investigating a new species?

1. No, but closely monitor trends and the market to see if a species can be processed and marketed under same conditions as catfish like tilapia, using company marketing and distribution channels. For example 10-12 years ago farmers' began experimenting with grass carp in the catfish ponds to control the weeds and algae. Therefore carp appeared in each load of catfish and the idea was to develop polyculture, raising two fish with market potential in the same pond. It failed because carp was too bony, hence limited market and farmers had problems harvesting the fish. Crawfish are raised down in Louisiana around New Orleans and 8-10 years ago experiments were conducted to grow crawfish in the rice fields of Mississippi Delta. Were it successful, the company wanted to process and market crawfish, but it was unsuccessful because crawfish prefer the environment 200 miles south in southern Louisiana. (Grass carp is also known as Chinese grass carp and in the North American vernacular as white Amur carp, after its place of origin, the Amur River system in Asia)

2. No. Not interested in other species development, unless it is an aquacultured plant or animal that could be grown on our farms.

3. No, but keep an open mind and grew carp for an opportunity market to satisfy a demand and hsb because a person with hatchery and production knowledge asked if he could experiment with hsb, but they were too hard to grow.

4. Yes, freshwater clams and another species of catfish.

5. Not a new species, but an improvement on the existing one. Company fish are grey, but the consumer prefers white. In 2000 we began cross breeding Rocky Mountain Whites from Tennessee with the greys and recently brought in broodstock from Louisiana, called Pearls. The Rocky Mountain Whites have no pigmentation, but are not Albino. They are all white and still tilapia. Colours as the determining factor and in Toronto tilapia of many different colours were sold and the whiter they got the higher the price. People recognise the shape of our fish as having a very thick meaty fillet. The innovation is to modify that look with the same bullet shape body confirmation but white in colour, so white it will "leap out" and nobody else will have a fish that looks like this and is coloured like this.

Summary

Is your organisation investigating a new species?

All companies had an open mind on investigating new species including freshwater clams and another catfish species. The critical factors when examining new species were its suitability for polyculture, that is, synergies with catfish production, processing and fit within existing marketing channels. Grass carp also known as both Chinese grass carp and white Amur carp, a fish used to control pond weeds and algae has polyculture attributes with market appeal to the live trade, but limited current opportunities. From all interviews emerged a feeling that the catfish industry had not reached its potential, needing more knowledge of catfish physiology and improvements in current industrial and mechanical solutions.

In other words not a new species, but improvements on the existing one.

8. How would you specify the design of a new product; what does a new product or species have to do?

1. Good FCR, tough, hardy and disease resistant, able to handle abuse and stress well. Catfish is a good example. The farm raised trout operation in Idaho, is centrally located, so the trout move almost from the pens to the processing plant, whereas in MS catfish are hauled from 50 miles away to our processing plant. Therefore trout does not have to be as hardy or as tough, because they don't get handled as much as catfish.

2. Be innovative and marketable in a new form.

3. Profitable and an improvement on the existing product.

4. Be environmentally sound and ideally grown in private water.

5. Cheaper than an existing one. The competition spends large amounts of money growing the fingerlings and for a farmer to buy fingerlings they cost 5-8 cents per fish, plus freight from the place of origin. Commercial fingerlings are half an inch.

Using Third World technology the company gets a 100 gram fish, five to six inches long, one quarter of a pound weight at a fraction of the cost. The competition is paying for a half inch fish. These fish are 5-6 inches long and already weigh 100 grams when stocked into tanks. The company grows three to four crops per year, whereas the competition has to hold on to nurse and artificially feed their fingerlings and suffer losses. Company losses take place in the pond and don't matter, because only the best are harvested. The biggest, the ones ready to go and cost the company between 2 and 4 cents per fish. The fish "census" is created in ponds, but the company cannot afford to feed the fish in ponds, because to gain weight they must be in tanks. So create the census in ponds then move them to tanks where they are fed very rapidly in that steep growth curve called the adolescent stage before they are sexually mature. Weight can be put on the fish at the rate of 100-120 grams of gain every four weeks.

Summary

Criteria for new product design

Mainstream industrial processes allow for a new product to be designed. A new fish species cannot be designed, but can be assessed under key design criteria or modified by genetic selection and hybridisation. For example a cross between striped sea bass *(Morone saxatilis)* and white bass *(Morone chrysops)* produces hybrid striped bass *(Morone saxatilis X Morone chrysops),* both a new species and a new species for aquaculture.

The design specification for a new species demands the species be tough, hardy, and able to handle abuse, stress and be disease resistant with good feed conversion ratio. The design for a species derivative product specifies it must be an improvement on existing species/products and with its derivatives be innovative and marketable in new forms. Ideally it should meet the criteria of triple-bottom-line accounting, economically successful, environmentally sustainable and socially beneficial. This may include production in private water to avoid the possibility of damaging public water.

9. How do you see the role of a product champion in developing a new species?

1. Important. Champions, both entrepreneurs and existing farmers have taken university and college research and convinced investment bankers the research suggests a species can be grown, processed marketed and sold. Farmers established co-operatives, built processing plants, hired marketers and progressed. Farmers tended to get involved through co-operatives and individual entrepreneurs through processing plants.

2. Important. For example, Joe Glover, Sr., (Greensboro, Alabama) received assistance from Auburn University in stocking channel catfish in some livestock (cattle) ponds on his farm. He grew the fish, harvested them, and "processed" them in the meat department of his small grocery store. He expanded his catfish farming, built a small catfish processing plant, and began selling to other grocery stores and catfish restaurants. In 1983 Farm Fresh Catfish Co had two processing plants and annual sales of about $ 40 million. Other catfish processing/marketing companies started in similar ways during this period.

3. Not important. The catfish industry evolved from catfish eating houses without a product champion.

4. A brave soul! 90% of them are wrong, but 10% are right. The catfish industry evolved, we didn't know why we did many things and still don't know.

5. A product champion absorbs a cost that everyone who follows in his footsteps is going to enjoy the fruits of his labour. Don't do it, don't be a product champion.

Summary

Product champions

Important (2), Not important (1), Brave (1), Don't be one (1).

The perception of product champions varies from important to brave, 90% are wrong, 10% are right, and those who follow product champions avoid the costs champions absorb. The term champion was poorly understood by respondents because it implies a code of chivalry possibly not applicable to the complex modern agribusiness environment, being both redundant and certainly archaic. The catfish industry evolved on a broad front with co-operative alliances forming and reforming during the process, with *product players* rather than product champions. Product players in developing catfish were Auburn and Mississippi State University, farmers, entrepreneurs, investment bankers who all combined their skills to attain a common goal of commercialisation. Farmers established co-operatives and both farmers and entrepreneurs built processing plants and hired professional marketers. It seems these pioneers reached and passed flash points, bottlenecks and stage gates as a group. Joe Glover, Sr. from Greensboro, Alabama is an example of catfish industry evolution. He received assistance from Auburn University to stock catfish in cattle ponds on his farm, where he grew, harvested and processed the fish in the meat department of his grocery store. He expanded his catfish farming, built a small catfish processing plant, and began selling to other grocery stores and catfish restaurants. In 1983 Farm Fresh Catfish Co had two processing plants and annual sales of about $40 million.

New product screening

10. What should be the selection criteria for a new species?

1. A hardy fish with market appeal that will convert feed, grow well and live well in the local environment. Some aquatic species might work for production but have no market appeal. For example carp is easy to grow but hard to market because it's too bony.

2. A fish that can meet customer's requirements on price, dependable year-round availability, quality, and value and can be marketed in restaurants, grocery chains and warehouse club stores, with the potential to become mainstream fish.

3. Passing a "desk top" review to ascertain its profitability.

4. Pond raised, environmentally sound, herbivorous that can use a vegetable protein diet, able to close lifecycle, consumer acceptance, limited bones, not large and easily filleted. The first bottleneck is closing the lifecycle successfully, which seems to be the problem with freshwater shrimp/prawns *(Macrobrachium rosenbergii).*

5. The question to be answered is, what species are the consumers already eating and enjoying and how can that be improved; faster cheaper and a higher quality, rather than; what species can I find to get consumers to eat and enjoy?

Suggest a fish with scales. The catfish has no scales and one third of the world's population, for religious reasons cannot eat a fish without scales. A fish with mild tasting white meat. Salmon has a problem with dark, strong tasting flesh and the fact that it is all dark meat. Few or no bones. Trout, grass carp and big head carp all have too many bones in the muscle. A fish that is not ugly and looks like a fish is well adapted and comfortable in its (aquaculture) environment. A fish that can be sold live with global appeal, but it must not be technologically challenging and be produced at a reasonable cost. Fresh and frozen fish may go out of fashion.

Summary

New species screening criteria

Market appeal (3), Good FCR (1), Fast growth (Easily produced/farmability (1), Adaptable to environment (1), Environmentally sound (1), Lifecycle closed (1), Herbivorous (1), Profitability (1), Taste (1), Robustness (1), Appearance (1), Live market appeal (1), Serve a global market (1), Availability (1).

A "desk top" review to match the fish with simple criteria before assessment under the key performance areas of:

1. Closed life cycle.
2. A scaled fish which looks like a fish, with mild tasting white meat and few bones.
3. Global appeal in the live market.
4. Good feed conversion ratio (FCR).
5. Sound growth profile, native or adapted to the local environment.
6. A balance between the realities of production and market opportunity.
7. Pond raised, environmentally sound and herbivorous, not carnivorous.
8. Satisfy chain requirements on price, dependable all year round availability, quality and value.
9. Marketed through a wide variety of outlets.
10. Synergies with current operations

The consumer is king and wants a white fleshed fish with scales, but without bones from which can be gleaned good fillets. Jews and Muslims cannot eat fish without scales, which eliminates catfish from about one third of the world's population. Salmon is too dark, its taste too strong and may be near the end of its product lifecycle. One respondent saw salmon as a cheap generic.

11. Do you think these criteria are generally applied?

1. Yes.

2. Yes.

3. Yes.

4. No. Money is wasted on high technology schemes like re-use of water coming off a plant and closed re-circulation systems which often encourage diseases and do not work properly. Catfish survives under severe living conditions which work for the species. Also initial culling is a problem. A carnivorous fish cannot be supported environmentally or economically.

5. No. Developers must produce what the consumer wants.

Summary

Selection criteria applied

Yes (3), No (2).

One of the two "no's" commented that money was wasted on re-circulation and other high technology systems. Initial culling of potential species was difficult and a carnivorous species could not be supported environmentally or economically.

12. Do you know of potential new species being poorly screened and subsequently developed without proper assessment?

1. Yes. Grass carp. It had poor market appeal (too bony) and needed additional industrial solutions. Assuming a market the catfish processors bought machinery to remove scales and pin bones, but the market didn't materialise. "Without proper assessment" is a good term, because catfish processors assumed because they were coming out of the ponds they could sell them, so spent the money, without properly assessing the market.

2. Tilapia and freshwater shrimp in Mississippi. The climate gets too cold for either, and there are no processing facilities in Mississippi

3. No, but the cost of production and market acceptance is critical.

4. Fresh water shrimp. Problems with raising juveniles in Mississippi's moderate temperatures.

5. Fresh water shrimp *(Macrobrachium rosenbergii)*, flounder and halibut. Too many people have great schemes based on how much the product sells for, but costing too much with a low survival rate. The equation is how many pounds produced per acre, per year, how much does it cost to produce a pound, per acre per year and consistent quality and quantity, the same poundage every week. In the poultry industry in the 1950s, a plant processed turkey, ducks, quail and chicken. Chicken is now so ubiquitous people think of poultry as being chicken, they don't even think of the other species and tilapia is going to have the same role in seafood.

Summary

Species poorly screened

Four knew of species being poorly screened and delineated them as follows: grass carp (1), freshwater shrimp (3), flounder and halibut (1).

Freshwater shrimp was nominated as classic failure during a site visit to the Thad Cochran Warmwater Institute in Mississippi in June 2000. There are problems raising shrimp juveniles in Mississippi's moderate climate and it gets too cold for good growout. The climate is also too cold for tilapia, but one respondent grows tilapia near MS gulf coast. Grass carp has little market appeal, is too bony, requiring additional mechanical/ industrial solutions to remove "pin bones," but one respondent grows it for a live fish market!

13. Should fish farmers examine the possibilities for new species as ongoing business research, or expand production of already established species?

1. Both. Production of existing species should continue to expand juxtaposed with new species research. Knowledge of existing species performing well in the agribusiness chain produces a virtual textbook enabling improvements to a fish with an established demand. No catfish or trout industry players are doing any research on their own trying to find another fish they can raise. They will wait until research has concluded it can be done, they may expand on that.

2. Stay with existing species.

3. Both, but to produce another species, there must be a processing solution as processing plants are species specific. Another species could be grown (without change) if it were sold live or packed in ice with no processing to produce fillets.

4. Both, fish farmers should keep an open mind on new species suggestions from universities.

5. Stay with existing species. Expand and add value to existing species by modification on the fringes. For example, Frank Purdue put marigold petals into his chicken feed and produced a golden fleshed chicken for which people paid a premium. This is similar to marbling our fish and getting brilliantly white flesh.

Summary

Expand existing species or develop new species

Both (3), Stay with existing species (2).

Two respondents supported new species research juxtaposed with expanding production of established species. Two opted to stay with existing species and one of the two added the rider that modification be done on the fringes to achieve a better product. Another respondent who is currently investigating new species inferred staying with established species whilst keeping an open mind on potential new species.

14. What attributes should an aquacultured fish have to survive and thrive in the market place be it domestic or export?

1. Ease of production and ready market.

2. Quality, price, value, all year round availability and dependable supply.

3. Satisfying consumers' tastes which in the US is a light flaky mild taste, but not fishy or strong, like cod, catfish, and pollock.

4. Few bones and white meat.

5. Cheap and high quality, like in Toronto where people look at the live fish selection of about 20-30 species and want to think they are choosing tilapia because they like it, not because its the least expensive. A fish should have a good fillet that holds together, grown by having it swim against the current every day of it's life which that cause the fish to develop a lot of muscles. Americans like to fool themselves they like chicken when buying it, not because it's the least expensive protein they can buy. More chicken is eaten in America than any other species and chicken passed red meat years ago, with a boneless, skinless ready to eat chicken. America produces the cheapest chicken in the world and exports to any country because production costs are so low.

Summary

Surviving and thriving in the market place

All respondents nominated customer satisfaction (5) as the dominant criterion

Others nominated ease of production (1), quality (2), price (2), value (1) all year round availability and dependable supply (1), ready market (1), desirable characteristics (few bones, white meat and good filleting properties) (2) all of which tie in with customer satisfaction.

New product marketing

15. Where is your market?

1. 99% of our market is domestic. Less than 1% of our industry sales are export and most of the export goes to either Canada or Germany. Those two countries make up about 90% of our export with some going to Japan. Money spent developing export markets in Germany proved it too costly and the industry was barely keeping up with the growing domestic demand and there is little or no interest for anyone to spend any money developing export sales. The real challenge will be building enough ponds and growing enough fish to take care of the domestic market.

2. The entire United States market with the south eastern United States targeted as the primary market. The heaviest consumption of farm-raised catfish is best represented geographically by an inverted "T," down the Mississippi River Valley through the Midwest and across the length of the American South from Texas to the Carolinas.

3. The South extending out to an 800 mile radius from Mississippi.

4. The whole United States described by an inverted "T" with southern tiers spreading east and west and the main bar following the Mississippi River north through the middle of the country. The North East corner and the North West corner are not good but California is a big market. About a quarter of the population lives in the South.

5. Sell through distributors to an export market in Toronto and domestic markets in the US including New York, Chicago, Phoenix, Huston, Dallas-Fort Worth and Atlanta.

Summary

Market location

The United States is the main market (5) with the South dominant (1).

The market area is generally described by an inverted "T" down the Mississippi River through the Mid West and across the South from Texas to the Carolinas (2). Less than 1% of catfish is exported to Canada, Germany and Japan (1). An expanding market for live fish exists in Canada, particularly Toronto (1). If pushed into a global market, catfish, a species without scales, for religious reasons is inedible to Jews and Muslims who constitute about 30% of potential world consumers (1). However export is costly and production barely meets domestic demand, therefore the task is expanding pond acreage and growing enough fish to supply demand within the United States. The North East and North West corners of America are not good markets but California is a large market.

16. Did you have to establish a market or was it already established with either wild harvested or other aquacultured species?

1. Southerners have always caught channel catfish out of their lakes and rivers. The Southern market was established because people knew channel catfish well, and it was a well demanded table product, therefore very easy market penetration in the early 1970s through to the early 1980s. But when expanding into the North East, New York and Boston, Chicago and on the West Coast it involved some true marketing, creating a demand for catfish which few people had heard of. Those who had thought it was a scavenger, caught one in one of the polluted rivers or lakes in the North East and inedible. So we had very easy market penetration in the early days of our industry back in the early 1970's, early 1980's.

2. The market in the South was established because Southerners knew catfish well. Elsewhere consumers' negative perceptions of catfish (bottom-feeding, scavenger) were changed by the Catfish Institute spending millions of dollars over 15 years in advertising and promotion, particularly consumer magazines. The considerable success this industry has enjoyed is based on market sales demand. That is consumers repeatedly buying the product.

3. Main market in the South was already established by wild caught catfish.

4. No, we established one by collecting $5 per ton on every ton of feed sold, forming the Catfish Institute and changing the image of the fish from a Southern fish to a national image by market development, advertising and public relations.

5. The market for bass was established and that for tilapia was establishing.

Summary

Established market

The cost of market penetration suggests the developer seek an established market, then grow the species under aquaculture conditions to deliver a fish of superior quality and lower price than its wild equivalent. The channel catfish entered an established market in the South (3) requiring development by the Catfish Institute (3). The Catfish Institute changed the image of catfish from a bottom feeding, scavenging Southern fish to a national image of a high quality fish (3).

17. How do consumers perceive your product?

1. Good all round well accepted fish.

2. A healthy, fresh, clean, good tasting fish. Industry success is based on market sales demand. That is many consumers repeatedly buying the product.

3. Well. The market is growing.

4. A good product and value for money.

5. Well. The future is in live fish.

Summary

Customer perception

All agreed catfish was perceived as a well regarded (clean, fresh, healthy, good tasting) fish (5) with one suggestion the future is in live fish (1). Industry success is based on market sales demand, that is many consumers repeatedly buying the product (1) and the market is growing (1).

18. Where is your competition and can your market grow?

1. Within a three-state area in the South. 95% of the catfish are raised within a 200-mile radius of Isola, Mississippi and 80% within a 75-mile radius. This is where the US catfish industry is from a production and processing standpoint. Part of it is because this is where there is a huge demand. Good markets exist in the North East and California, but catfish are difficult to grow anywhere else but the South. Tilapia is now also competition. Initially the only tilapia coming in to the States was frozen, not much was produced and cost per pound was high and not seen as a direct competitor. Now tons of it is flown in fresh from Central America to Miami, New Orleans and Los Angeles twice a week, therefore grocery stores get fresh tilapia delivered to them twice a week and available at about the same price as catfish, in some cases lower. Five years ago, tilapia was $4-$4.50 per pound and catfish $3 per pound wholesale. Live tilapia is sold on the West Coast to Orientals mainly.

2. Other catfish processors in the South.

3. Catfish farmers and processors in Mississippi, Alabama and Arkansas, where probably 90% of the farms and plants are located. Volume has grown equal to, or more than the industry volume and we have been able to expand our processing at a higher rate than the industry has grown. No other fish competes with catfish in the South, but (the currently) wild caught freshwater species bass and crappie could compete if raised on a commercial basis (Crappie=white crappie *Pomoxis annularis* Rafinesque 1818). No other obvious new species. Farmers will concentrate on the catfish and fight imported "catfish" species from Viet Nam which have lowered prices.

4. Catfish had a niche market between low priced and high priced fish. When catfish started, cod had the biggest consumption in the US and was a competitor but has slowly disappeared and replaced by competition from cheap salmon. Wild caught marine fish are potential competitors but tend to be consumed near the coast so the heartland of America is a better market for catfish. Tilapia in ponds, which are at the mercy of the live haul trucker and the changing seasons because the cold winter kills tilapia and ponds cannot be kept warm. Tilapia is best grown indoors in intensive closed re-circulation systems. The largest in North America right now is a company called Blue Ridge Aquaculture in Martinsville, Virginia. Before the cost of energy went up last year Blue Ridge was spending $1000 a day in propane cost heating up well water from 52 degrees to 78 degrees. When energy costs went up he went from $1000 a day to $4000 a day!

The company does not have to make the market. It has to supply the market. There are more Hispanics, more Orientals and more Occidentals, European descent people who are switching from dead fish to live fish because they see (as they go into supermarkets) what the other nationalities and races are eating. Their consumer education is occurring and the company does not have to do it. 100% high quality fish doesn't smell fishy, nor taste fishy. Fish from ponds swimming in their own waste and fish from closed re-circulation systems swimming in their own waste will have an off flavour unless they are purged, which is expensive and most people cannot afford to do it. The company's single pass flow through system, grows a fish without a muddy off flavour.

Summary

Competition and market growth

The question; "can your market grow?" was answered by all respondents throughout the interviews, where four out of five thought the catfish market would expand. Only one respondent directly answered the first part of question 18 under its heading. He stated no other species competes with catfish in the South, company output has grown equal to, or more than the industry percentage volume and company processing expands at a higher rate than industry percentage growth. Though no new species were obvious, potential competition may come from freshwater species bass and crappie if (economically) farm raised (1). Industry future is to concentrate on catfish whilst fighting imported "catfish" species from Viet Nam which have lowered prices (1). Wild caught marine fish are potential competitors but tend to be consumed near the coast, therefore the heartland of America is a better market for catfish (1). Respondents generally agreed competition comes from catfish farmers/processors within the area of three southern states, Mississippi, Alabama and Arkansas (3). 95% of catfish are raised within a 200-mile radius of Isola, MS and 80% within a 75-mile radius. Catfish are difficult to grow anywhere but the South. When catfish started, cod had the largest consumption in the US and catfish secured a niche market between low and high priced fish. Competition from cod slowly disappeared, now replaced by competition from cheap salmon (1). Two others cited alternate species competition comes imported fresh and frozen tilapia (at the same price as catfish) (1), and live tilapia (1). Evolving demand for live tilapia comes from more Hispanics, Orientals and Occidentals, switching from dead fish to live fish because they see (in supermarkets), what other nationalities and races eat (1). Their consumer education occurs without the company having to do it (1).

19. To what extent does the market drive new aquaculture species development?

1. The industry in the United States has grown what grows well (production driven) then marketed it, rather than responding to market demand (market driven).

2. There will always be an opportunity for new aquaculture species to be successfully introduced in the American market. If the product has the right product qualities, and is perceived as value to the consumer, it can be successful.

3. The market doesn't drive new species development other than to ensure a market exists.

4. It doesn't, it's not quite the same as selling a new cereal product. You've got to build a market if you're coming with a new species, particularly in fish. Fish is not a necessarily cheap product and the US beef industry says 50% of American housewives have never bought fish. The way they think can change but first they must be shown how to use the fish.

5. Very much. The producer should look at what the customer is eating and then improve on that.

Summary

Market demand driving new species development

Two (2) respondents thought market demand drove new species development. The opportunity always exists for a developer to improve on what consumers' are already eating with a new species showing the right product qualities and perceived as value by customers. Three (3) said market demand does not drive new species development other than to ensure a market exists. This means entering an established market or building a market. One respondent said the aquaculture industry in the United States grows what grows well (production driven) and markets it, rather than responding to market demand (market driven). According to statistics form the US beef industry, 50% of American housewives have never bought fish. Building a market with them means changing they way they think about fish and showing them how to use fish.

20. In new species development, how does the developer balance market demand for size, quality and continuity of supply against the realities of production?

1. Evaluate production and marketing costs against profitability.

2. Growers supply fish (for processing) ranging from 1/3 lbs to 4 lbs live weight, a size range often narrowed by growing and harvesting practices. Customers and markets are developed for different sizes/weights of fillets and whole H & G fish both sold fresh and frozen. The sales challenge is to find profitable customers for all these different sizes of fish which is a constantly changing, balancing act.

3. Evaluate production and marketing costs against profitability.

4. The producer tries if he can, but catfish doesn't have size control so the processors are forced to try and find a market for different size fish.

Costs run higher every time you try to meet a smaller market for example a processing plant was selling 1200 different items priced differently, now its down to under 200. To survive in catfish, you try and find the markets you can serve. Find a market for by products.

5. Don't take on too much! There is always the temptation on the part of so many people to say; "It hasn't been done before therefore I should try to do it a new way." The producer often needs to take a unique amalgamation of existing technologies that bring the lowest possible cost. Too many people want to grow oranges at the North Pole. Some of the company's competition is trying to grow fish in the desert, which is not known for its abundance of water, by definition. That is growing oranges at the North Pole.

If markets are expanded too fast developing too many customers, the producer cannot be all things to all people. It is important to hold back and stay with what can be produced. That way a higher price can be commanded and greater loyalty demanded on the part of customers. This company top dresses feed with probiotics and vegetable oil to create a marbling in the flesh of the fish, like marbling red meat. The fillet when compared to the competition, domestic or international looks milky white, theirs looks translucent, a pale grey or blue, like looking into an ice cube. The milky white fillet outsells the competition 5:1, side by side in the same display case. The label can be moved, imported or domestic and customers go back to milky white. Consumers eat with their eyes and then with their mouth.

Summary

Production meeting market demand

Two (2) said it was a balancing act to find customers for a wide variety of species products. For example, to meet a smaller market a processing plant was selling 1200 different items priced differently, now it's rationalised to less than 200 items. To survive in catfish, the company must find and supply the markets it can serve and find markets for less attractive pieces of the catfish carcass. Three (3) thought that in new species development the developer balanced market demand against the realities of production by evaluating production and marketing costs against profitability. One of the three cautioned against high technology, over engineered solutions, using the example of growing oranges at the North Pole. It can be done, but not viable when evaluating production and marketing costs against profitability. For example growing fish in the desert, not known for its abundance of water equates to growing oranges at the North Pole. Often a unique amalgamation of existing technologies brings lowest cost. Avoid expanding markets too fast and developing too many customers, and stay within company production capacity, thereby commanding a higher price and demanding greater customer loyalty.

21. How should the aquaculture industry innovate?

1. The marketing challenge outside the South was perception. People thought catfish was a bottom feeder and a nasty fish. Catfish had to be introduced to the whole nation. That accomplished, the next marketing challenge was to innovate by offering the product in more convenient ways by value adding, for example, better packaging and pre-cooking allowing for faster preparation.

2. Consolidate. There are too many companies, none of which are financially strong enough to do a good job of marketing and new product development. For example mainstream agribusiness companies like Tyson (chicken), Hormel and Smithfield (pork), and IBP and Con Agra (beef). The catfish industry has no big, successful companies with large marketing and R&D budgets.

3. Establish a well financed research team along university lines with aquaculture specialists to evaluate new species. Corporations won't do it so the initiative should come from farmers but they lack the university team approach. The catfish industry in the South hopes to continue growing and probably should consolidate, but is small overall compared to other food industries.

4. Investigate new ideas. In new species development first review the cost restrictions. Then look at the other areas. For example trout farmers are limited by the amount of fresh water available to them and shrimp farmers have disease problems. Innovative mechanical and industrial solutions are needed in fish handling, harvesting and marketing could cut costs in half. For example a 100% harvest at the optimum growth stage with all fish a certain size produces processing efficiencies. The chicken industry operates within a two ounces range. Were fish harvested within a two ounces range, production numbers go up, processing costs come down and conversion costs come down. In cotton value chain the research facility in North Carolina was trying to fit the consumer's needs, but now helps the textile mills adapt equipment where they can handle the raw material (cotton) more effectively, thereby matching the characteristics of the cotton, rather than the characteristics of the consumer.

5. At the margins, working on the edges. The company is working on some modifications of its current production, improving, adding to, but not switching significantly. Company fish are grey, but the consumer prefers white. In 2000 we began cross breeding Rocky Mountain Whites from Tennessee with the greys and recently brought in broodstock from Louisiana, called Pearls. The Rocky Mountain Whites have no pigmentation, but are not Albino. They are all white and still tilapia. Colours as the determining factor and in Toronto tilapia of many different colours were sold and the whiter they got the higher the price. People recognise the shape of our fish as having a very thick meaty fillet. The innovation is to modify that look with the same bullet shape body confirmation but white in colour, so white it will "leap out" and nobody else will have a fish that looks like this and is coloured like this. Innovation should happen in the segmentation structure of the aquaculture value chain; making changes that define the relationship between producer and buyer by eliminating redundant chain segments.

Summary

Innovation in aquaculture

Eight different areas of innovation throughout the value chain were identified amongst the five respondents:

1. Consolidate catfish companies enabling economies of scale to achieve large research and development budgets for new species and new product development.

2. Establish a well financed research team along university guidelines to evaluate new species.

3. Investigate new ideas

4. Change consumers' perception of catfish (and new species) and products by advertising and promotion

5. Add value, for example, better packaging and pre-cooking allowing for faster preparation of catfish.

6. New industrial and mechanical solutions to lower costs and deliver better consumer value

7. Changes in value chain segmentation structure and re-defining the relationship between producer and buyer by eliminating redundant chain segments.

8. Make incremental improvements by working on the margins, rather than switching product offerings.

New product processes

22. Do you have a formal process for new product development?

1. No.

2. No. Pre-breaded catfish fillets and marinated catfish fillets more likely had a more formal new product development process than the evolving of the farm-raised catfish industry.

3. No.

4. No.

5. No.

Summary

Formal process for new product development

None of the survey companies had a formal process for new product development. However one respondent noted that value added product, for example pre-breaded catfish fillets and marinated catfish fillets more likely had a formal new product development process than the evolution of farm-raised catfish.

23. How should the developer of new aquaculture products involve future potential customers in the NPD process?

1. Customers should be asked, what if? "If we had a product like this would you buy it?" or "What would you like to see us develop?" New packaging and new products are needed but must be developed with customer input. Think tanks should not only produce creative ideas but sift through those obtained from consumers. Both sources of ideas should come in the main from market research. The option, given little demand is to spend money creating the demand. The "market safe" new product is one developed at the "request" of the market, established by a demand so great as to deliver volume sales. Years ago, the company developed canned catfish and catfish sausages which were excellent products, but lacked the resources of a huge food company to market them and educate the consumer, about the product's quality. Some products, like these did not work years ago, may work today and were probably premature. This company rarely develops a new product, then only when specifically asked for it

2. Before making any investment, approach potential purchasers of the new species and get their reaction about the marketability and whether they would purchase the product. Also visit key large customers and explore with them their ideas about the proposed product, and what could be done differently.

3. The company needs to find out what customers want. The customer who buys carp requests size and time of delivery. A new species should be developed for an existing market already so the developer should know product specifications, for example fillet size.

(Carp=Grass carp also known as Chinese grass carp and in the North American vernacular, white Amur carp)

4. In the cotton industry if there is a value chain problem in a dyeing firm or a weaving firm (for example breakdowns) and the problems are overcome, the firms then need more cotton. It's a study of the whole market to see where people can be helped achieve a break through. But value chain players with specific problems are needed. The fish industry is not structured that way. It's fragmented and a merchant may be handling 100 different species and is unlikely to specialise in the value chain of any one particular fish.

5. Find out what they are already eating and improve on that.

Summary

Customer involvement in the new product development process

All respondents agreed that future potential customers should be involved in the NPD process (5). Ideally a new species should be developed for an existing market so the developer knows product specifications, for example fillet size (1). One respondent identified customers as the whole market and using another agribusiness industry as an example highlighted relationship marketing throughout the value chain as an important area of customer involvement (1). He cautioned that because the fish industry is unstructured and fragmented a merchant may be handling 100 different species and is therefore unlikely to specialise in the value chain of any one particular fish (1). Various methods of customer involvement were cited, most significant was the "market safe" new product, one developed at the "request" of the market and established by a demand so great as to deliver volume sales (3). Think tanks should not only produce creative ideas, but also sift through those obtained from consumers' (1). Developers should approach potential purchasers of the new species for their reaction on its market appeal, explore ideas with them about what could be done differently and whether they would buy the product (1). One company developed "in house," canned catfish and catfish sausages but lacked the resources of a huge food company to market them and educate the consumer about the product's quality. These excellent products failed and the company concluded they were premature. The failure of which may have been overcome by better market research. This company develops a new product if asked, and another company surveyed grows an alternate species, grass carp only because it was requested to do so for a specific market.

24. When should representatives from all company functions (research and development, production and marketing) become involved in the NPD process?

1. At the beginning.

2. When the decision is made to develop a new product, all company functions should be involved from the beginning.

3. At the beginning to ensure nothing is overlooked.

4. Firm not organised in a corporate form for that.

5. All staff should be involved from the beginning and their activities co-ordinated by regular staff meetings. In this case company biological staff and production staff don't keep track of costs. For example, recently when running short of some fingerlings the production department wanted more fingerlings and the biological department said we can do that by setting up a nursery. The company had to ask at what cost?

Summary

Cross-functional representation in the NPD process

Four respondents stated representatives from all company functions should be involved from the beginning to ensure nothing is overlooked. The fifth respondent said his firm was not organised in corporate form to undertake the process.

25. How important is the new aquaculture product "launch" into the marketplace?

1. Correct product launch is critical but needs money if entering a new non established market. Tilapia has proven that with good marketing and retailer support an unknown species can be introduced to an unfamiliar market and do well.

2. The launch is critical, 90% of new products launched fail within the first ninety days. Therefore, sufficient marketing funds, extensive consumer testing, promotion and marketing materials, sufficient product availability, and a sincere understanding with enough of your customers to stock the product throughout the launch phase. Everything must be in place before you launch.

3. Don't know

4. Important, the company is launching a new catfish. Launching an agricultural product is different from launching a Microsoft product as in agriculture the new product is eased in. The problem is achieving production levels high enough to launch and justify money spent on advertising in getting the product embedded in the value chain which may take years. During that period the product has to produce income.

5. Its so important it should not be done.

Summary

Product launch

One respondent did not know whether the product launch is important or not. Another said the product launch is so important it should not be done!

Of the remaining three, two saw the product launch as critical and one rated it as important. The launch needs sufficient marketing funds, extensive consumer testing, promotion, marketing materials and sufficient product availability. Launching into an established market is preferable to a non-established market. Entering a new market requires money. Tilapia has proven that with good marketing and retailer support an unknown species can be introduced to an unfamiliar market and do well. Launching an agricultural (aquaculture) product is different from launching a Microsoft product because in agriculture the new product is eased into the market. The problem is achieving production levels high enough to launch and justify money spent on advertising getting the product embedded in the value chain. This may take years and during that period the product has to make money.

26. How does new species development feature in the future of aquaculture?

1. That's where the growth in both seafood and freshwater species has to come from. Most important due to the decline in wild caught fresh and saltwater species. The problem is to pick a suitable wild caught species for aquaculture. There's a huge market for redfish (redfish=red drum *Scianops ocellatus* Linnaeus 1766) in the US and in the South about two years ago, netting for redfish was banned. The sport fisherman catching them in the marshes of Louisiana and Florida lobbied and stopped commercial fishermen, so there was a species, a viable commercial species no longer available. Louisiana State University (LSU) has spent time and money researching redfish with limited success, it takes too long to get a mature adult and then the growout is too slow. But again there is a case where if they could be reasonably done there would be a tremendous market for it. Whenever there is a market for a species its development will be investigated and researched to ascertain if that fish can be raised in an aquaculture environment.

2. The American market will always be an opportunity for the introduction of new aquaculture species with the right product qualities, particularly consumer value.

3. Declining supply from the ocean will cause price rise, opening the opportunity for new species development as an alternate to wild caught.

4. Money is being wasted on looking at species without examining the cost barriers. Catfish has obvious break through points and satisfies at least 30% of the fish market. The question then is should money be spent on developing more species. If fish were as different as oranges and apples you could see a distinction. But most fish is a white fleshed muscle, a question of flavour and not that distinguishing.

5. It features only in incremental changes, not in major changes.

Summary

New species development and the future of aquaculture

Three agreed new species development is a solution to declining wild caught stocks and all three opined that the new species should replace the same wild caught species in decline. Wherever there is a market for a species its development should be investigated and the research done to see if that fish can be raised in an aquaculture environment (1). One respondent observed catfish satisfies at least 30% of the fish market and questioned spending money on developing new species rather than improving on catfish. He observed that, if fish were as different as oranges and apples, there is a distinction, but most fish are a white fleshed muscle and flavour is not distinguishing. The last respondent said new species development features only in incremental changes, not major changes. These two answers imply sticking with an easy to grow white fleshed "generic" fish and improving on it.

New product development agribusiness value chain

27. Why is catfish successful in the United States?

1. Thirty years ago when Auburn University was trying to find a perfect freshwater fish to be raised in North America, funded by government grants, *they did not have a clue it would be a channel catfish.* The University thought it would be a sunfish, bass or a trout. But after testing all these freshwater fish, the channel catfish converted feed better, was hardier and therefore was promoted to grain-based feed companies like Goldkist and Conagra which in turn promoted raising of catfish to farmers. The South has the right environment, the right climate and the right water supply. There are very few other environments in the United States where catfish can be produced as well as in the

Mississippi Delta. Even with the good markets there it is not a potential species for anyone to raise on the West Coast or in the North Eastern part of the United States. Catfish is almost prehistoric, extremely tough and immune to most fish diseases and therefore doesn't require some chemicals often used in aquaculture. In the South the channel catfish was regarded as the premier catfish, but in the remaining two thirds of the US it required pull marketing, creating demand using food editors of major trade publications to popularise the fish.

The retailers, like Krogers, Safeways, Winn Dixie pushed the product to develop more and stable seafood sales, because of supply problems with fresh snapper, flounder, sole and grouper. Catfish tasted good and could be delivered twice a week, 52 weeks of the year. Therefore the retailers promoted and pushed catfish creating demand and new markets. The fish was affordable at a lower cost than a lot of the ocean fish with a stable price.

2. Catfish has the characteristics American consumers like; white, flaky meat, little or no bones, mild/bland in flavour, easy to portion size and readily available, at a stable price. Its neutral flavour allows chefs and cooks to personalise the fish with their own culinary creations. The price is generally stable and supply adequate.

3. It was already a well-known and popular recreational fish. Enhancement by farming and feeding improved and controlled its growth, size, quality, freshness and availability. Americans like a mild fish without as fishy taste or smell. Catfish taste is enhanced by a variety of cooking options. The US wants healthy food, catfish is high in protein and low in fat and research shows fish to be healthier than some other meat.

4. Catfish was already well known in the South, someone learned how to produce fingerlings and grow them out. Also it's herbivorous, rather than carnivorous and can live under pretty drastic water conditions. The right species to select for aquaculture.

5. The catfish was an African-American fish. It caught on and started to be eaten by the white American population. It spread because it was cheap and easy to grow, not because it had any great appearance, not because people thought it was a great tasting fish, the flesh is rather soft and mushy and the only time it really has any cohesiveness is when it is battered and fried.

Summary

Catfish success

All agreed that catfish succeeded in aquaculture because the Southern population knew the fish, caught and ate it regularly, enjoying it even more after enhancement by farming. Most significant is that catfish emerged as an unlikely contender from a suite of potential new freshwater fish investigated by Auburn University in the 1960s.

The data revealed that in the screening process catfish achieved superior ratings to other candidates on the following criteria:

Well known in the South of the United States (3)

Good flesh quality (2)

Robust (2)

Good feed conversion (1)

Well suited to the environment (1)

Easy to farm, tolerates poor quality water (1)

Immunity to fish diseases (1)

Healthy fish to eat (high in protein and low in fat) (1)

Easy to produce fingerlings (1)

Herbivorous (1)

One respondent saw catfish as almost prehistoric in its robustness. Catfish is mainly herbivorous minimising fishmeal consumption, an environmentally unfriendly impact (according to one respondent), that carnivorous species requirements for such have on wild fish stocks. This important advantage in the largely agrarian South, allows grain farmers and millers the opportunity for integration into the catfish value chain, facilitating a supply of high quality well-priced feed, which levied at $5 per ton enabled establishment of the Catfish Institute. The South, catfish home environment, has the optimum environment, climate, and water supply/quality and few places other than the Mississippi Delta suit catfish production in the United States. Catfish has the characteristics American consumers like; white, flaky meat, little or no bones, mild/bland in flavour, easy to portion size and readily available at a stable price. Catfish taste is enhanced by a variety of cooking options, lacking a fishy smell, its neutral flavour allows chefs and cooks to personalise the fish with their own culinary creations. In the South channel catfish is regarded as the premier catfish, but in the remaining two thirds of the US it required pull marketing, creating demand using food editors of major trade publications to popularise the fish. The retailers, like Krogers, Safeways, Winn Dixie pushed the product to develop more and stable seafood sales, because of supply problems with fresh snapper, flounder, sole and grouper. Catfish characteristics satisfied consumer demand. The species was affordable (at a lower cost than many ocean fish) and could be delivered twice a week, 52 weeks of the year. Therefore the retailers promoted and pushed catfish creating demand and new markets. Enhancement by farming and feeding improved and controlled its growth, size, quality, freshness and availability. Americans like a mild fish without as fishy taste or smell.

United States consumers want healthy food, catfish is high in protein and low in fat and research shows fish to be healthier than some other meat. One respondent saw catfish as an African-American favourite fish, consumption of which diffused to white Americans and spread because it was cheap and easy to grow. He saw catfish as a generic fish lacking appearance, taste and texture, with soft, mushy flesh made cohesive only when battered and fried.

28. Was a new product development process applied to catfish?

1. No, it evolved and good marketing was critical. Tilapia is becoming popular because it has the same marketing advantages catfish had, retail grocer stores were looking for another species and they could get tilapia regularly. Tilapia now competes with catfish, but five years ago, tilapia was $4-$4.50 per pound and catfish $3 per pound wholesale. Now tilapia produced in large quantities is about the same price as catfish and, in some cases it's lower than our catfish prices. Live tilapia has a market on the West Coast to Orientals and Central America produces large volumes flown into Miami, New Orleans and Los Angeles fresh, twice a week. This has increased tilapia's market share.

2. No, it evolved, however, pre-breaded catfish fillets and marinated catfish fillets more likely had a formal new product development process than the evolution of the farm-raised catfish industry.

3. There was no master plan. Farm raised catfish evolved from a recreational fishery to ponds beside catfish restaurants where people caught their own fish, often fed to make them larger and more appealing. Australian yabbies are similar to the way catfish started;

people ate them from channels, ponds and creeks then began raising and selling them into a ready market. Farming enhances a species already occurring in an area thereby making them available at similar sizes, superior quality and year round availability not previously available, enabling the market to expand. The new product is the enhanced product. A new species can be developed that nobody knows much about, but introducing it would be a slow process because of the marketing challenge of getting people used to it, whereas if people like an existing species enhancement only improves its appeal.

4. No, one little event led to another and finally catfish was culled down. The industry probably went for twenty years without really understanding what they had. In many ways the industry still does not understand why it's been successful.

5. No. It evolved.

Catfish

New product development applied to catfish

All respondents agreed that no new product development process was applied to catfish; the new species and its industry evolved (5), but marketing was critical (1). "One little event led to another and finally catfish was culled down. The industry probably went for twenty years without really understanding what they had. In many ways the industry still does not understand why it's been successful." (1). The "new product" is a wild species living in an area, enhanced by farming, thereby delivering superior quality, available at similar sizes with a year round supply not previously possible, enabling market expansion. An unknown new species, if developed, requires deliberate introduction, a slow process because of the marketing challenge getting people used to it. If people like an existing species, enhancement by aquaculture only improves its appeal, making the new product the enhanced product (1). Pre-breaded catfish fillets and marinated catfish fillets more likely had a more formal new product development process than the evolution of the farm-raised catfish industry.

29. The value chain is a series of stages or events from selecting a species for culture, to marketing that species; what are the critical components of the catfish value chain and how are these linked?

1. The available land, water and feed mills, locally available feed all linked by the provision of jobs to local (often otherwise disadvantaged) people. Catfish uses heavy clay soil no good for cropping and catfish increases the value of that land. Catfish then helped real estate, well drillers, feed mills and grain farmers. The hatcheries aren't a big deal, but catfish employs many people who would otherwise be on welfare. The catfish industry injects millions of dollars into the economy of the State of Mississippi (MS) and helps everybody with big dollars turning in a community. Catfish has saved many in the agricultural community formerly and currently growing cotton, soybeans and corn and those guys are not making any money. Catfish is a good example. The farm raised trout operation in Idaho, is centrally located, so the trout move almost from the pens to the processing plant, whereas in MS catfish are hauled from 50 miles away to our processing plant. Therefore trout does not have to be as hardy or as tough, because they don't get handled as much as catfish.

2. Learning pond culture technology primarily started at Auburn University and Mississippi State University and word of mouth from farmer to farmer. Learning processing and marketing (including personnel) technology initially adapted from the poultry industry. Later processing technology came from Baader Machinery Co., Germany, the world's largest seafood machinery company. Infrastructure located in the catfish farming and processing regions, including catfish feed mills, research stations, financiers (willing to finance pond and processing plant construction and expansions) and universities funding catfish research and training students for aquaculture careers.

3. Integration with a feed company (in our case part ownership) milling feed from locally grown grains. The critical link is a disastrous event like chemical contamination of the fish and reported by the media. The company raises half its fish and buys the other half from other farmers. Company policy is to hold onto its own fish when the market is down and buy from other farmers. When the market improves it processes its own.

4. Feed at $200 per ton or 10 cents a pound is half the cost of production if the conversion is right. The industry does not know enough about potential species and in value chain construction there may not be an incentive for more species. The new species in the chain either has to be different or cheaper. The research farm at our feed mill is devoted to feed additives (vitamins and minerals) as the corn and soybean are the cheapest source carbohydrates and protein for catfish.

5. There are three segments to the *live* fish business which is the future of seafood; the grower, the marketer to the end user who could be the wholesaler or the supermarket retailer and the connection between the two which was the long haul truck driver. The truck driver needs specialised equipment costing between $80,000-$100,000 for live haul, requiring tanks, oxygen and lightweight (aluminium) construction with a special engine and gear ratio. Having invested so much money, the live hauler will align himself with a buyer of seafood, because growers of seafood are sometimes unreliable and seasonal. The company has achieved reliability to the customer but had to develop an alternative to the live haul trucker create a linkage between the grower and the buyer and negate the importance of the trucker. Insulated, "fork liftable" boxes enables harvesting fish from tanks and eliminates further handling. The buyer sells live fish out of those boxes returning the empties to the company. Converting an 18 wheeler for hauling live fish takes 30 minutes. Whoever quotes the lowest for freight gets the job. So rather than dealing with a highly specialised piece of equipment a generic truck can convert to live haulage in minutes. That method was developed in response to segmentation adverse to company. Once buyers had equipped their store to handle company totes and oxygen in a modular form (to keep the fish alive) they could not accept fish from another grower, so they were locked in to buying from the company. Innovating in terms of the segmentation structure of the industry and responding to change needs help to define the relationship between the company and the buyer by taking out one of the chain segments. Re-configuring the chain can happen at any time. The transportation segment is vital because the typical arrival time (at the buyers) required in North America is a Friday or Saturday arrival for the weekend, because the pay cheque is paid on Friday. The live inventory should not be carried into Monday, Tuesday and Wednesday of the next week so the fish sold as soon as they came off the truck. All of the trucks cannot be ready for a Friday-Saturday arrival, and a company can't afford to own a truck if it's not busy the rest of the week.

Another part of the value chain is that in the Unite States, the Department of Food and Drug Administration is in charge of seafood. They issued a set of regulations called HACCP and HACCP regulations went into effect in December 1997. What HACCP regulations were trying to do is get better control of how and where seafood is processed.

They thought that by putting HACCP rules in place it would be like the poultry industry, there would be a new large centralised processing plant and they wouldn't see all the processing scattered to the four corners of the earth. Diabolically what happened is just the opposite of what they thought. Instead of embracing that for fresh and frozen, the industry has adopted the live business, because so long as it's live, there's no processing involved and no record keeping. At the turn of the century chicken was sent live by rail car to the butcher and the butcher processed the live chicken into whatever the consumer wanted in the butcher's shop. This is what's happening with the live fish business in North America, back to the butcher's shop kind of processing. The Federal inspection control has become fragmented as opposed to centralised and easier to control.

Summary

Critical components and linkages in the agribusiness value chain

Feed mills (4), Land (1), Water (1), Locally available grains for feed (2), Alternate industry to cropping (1), Research institutions (2) Technology transfer from poultry (1), Technology transfer from seafood processing overseas (1), Financiers (1), Strategic alliances with feed mills (1), Value chain configuration (1), Provision of jobs (1).

Respondents revealed clues to the value chain structure and operation throughout the interviews without restricting their answers to the specific section on the agribusiness value chain. The first saw components as available land, water and feed mills supplied by local grain, all linked by the provision of jobs to local (often otherwise disadvantaged) people. Catfish ponds use heavy clay soil that increases the value of land no good for cropping, which in turn benefits real estate, (well) drillers, feed mills and grain farmers. The industry injects millions of dollars into the economy of the State of Mississippi, the poorest in the Union. Catfish has saved many farmers formerly and currently growing cotton, soybeans and corn. They now either grow catfish or supply the industry with grain. The second respondent thought learning pond culture technology at Auburn University and Mississippi State University and adapting processing and marketing (including personnel) technology from the poultry industry were important linkages. He also rated the developed infrastructure located in the catfish farming and processing regions, including catfish feed mills, research stations, financiers (willing to finance pond and processing plant construction and expansions) and universities funding catfish research and training students for aquaculture careers.

The third saw integration with a feed company (part ownership) milling feed from locally grown grains as an important re-integration with the value chain.

The fourth followed on the subject of feed at $200 per ton or10 cents a pound, noting its value as half the cost of production if the conversion is right. He stated the industry does not know enough about potential species and in value chain construction there may not be an incentive for more species. The new species in the chain either has to be different or cheaper.

The fifth delineated three segments in the live fish business, which he regards as the future of seafood. These segments are the grower, the marketer to the end user (wholesaler or supermarket retailer) and the connection between the two, the long haul truck driver. The truck driver needs specialised equipment costing between $80,000-$100,000 for live haul, requiring tanks, oxygen and lightweight (aluminium) construction with a special engine and gear ratio. Having invested so much money, the live hauler will align himself with a buyer of seafood, because growers of seafood are sometimes unreliable and seasonal. The company has achieved reliability to the customer but had to develop an alternative to the live haul trucker to create a linkage between the grower and the buyer and negate the importance of the trucker. Insulated, "fork liftable" boxes enable harvesting fish from tanks and eliminates further handling.

The buyer sells live fish out of those boxes returning the empties to the company. Converting an 18-wheeler for hauling live fish takes 30 minutes. Whoever quotes the lowest for freight gets the job. So rather than dealing with a highly specialised piece of equipment a generic truck can convert to live haulage in minutes. That method was developed in response to segmentation adverse to company. Once buyers had equipped their store to handle company totes and oxygen in a modular form (to keep the fish alive) they could not accept fish from another grower, so they were locked in to buying from the company. Innovating in terms of the segmentation structure of the industry and responding change needs helps define the relationship between the company and the buyer by taking out one of the chain segments. Re-configuring the chain can happen at any time. The transportation segment is vital because the typical arrival time (at the buyers) required in North America is a Friday or Saturday arrival for the weekend, because the pay cheque is paid on Friday. The live inventory should not be carried into Monday, Tuesday, and Wednesday of the next week so the fish sold as soon as they came off the truck. All of the trucks cannot be ready for a Friday-Saturday arrival, and a company cannot afford to own a truck if it's not busy the rest of the week.

Another part of the value chain is that in the Unite States, the Department of Food and Drug Administration is in charge of seafood. They issued a set of regulations called HACCP and HACCP regulations became effective in December 1997. What HACCP regulations were trying to do is get better control of how and where seafood is processed. They thought that by putting HACCP rules in place it would be like the poultry industry, there would be a new large centralised processing plant and they wouldn't see all the processing fragmented. What happened is just the opposite of what they thought. Instead of embracing that for fresh and frozen, the industry has adopted the live business, because so long as it's live, there's no processing involved and no record keeping. Chicken is processed industrially in the United States now, but at the turn of the century chicken was sent live by rail car to the butcher and the butcher processed the live chicken into whatever the consumer wanted in his butchers shop. The live fish business here in North America is back to the butcher's shop kind of processing. The Federal inspection control has become fragmented as opposed to centralised and easier to control.

From the responses to Question 29 the following simple chain is as apparent.

1. Research and development
2. Hatcheries
3. Sites
4. Water
5. Feed
6. Processors
7. Market
8. Supporting infrastructure
9. Industry associations

Catfish appears to satisfy the modern concept of triple-bottom-line accounting of economic success, environmental sustainability and social benefit.

30. Could another species achieve catfish's success?

1. Yes, redfish=red drum *(Sciaenops ocellatus)* and hybrid striped bass *(Morone saxatilis X Morone chrysops).* Hsb may be successful if raised in large quantities to reduce production costs. Bass needs no introduction to the market. Any fish must be produced at an affordable cost.

2. Yes, but difficult. Catfish has almost no limits to supply and a large untapped market remaining in the U.S.

3. Crappie is a possibility. It may have an opportunity to match catfish over the next thirty years.

4. Perhaps, but tilapia and striped bass have come and gone. Other species have difficulty matching catfish cost levels.

5. Yes.

Summary

Another species achieving catfish success

Yes (3), Possibly (2)

One 'yes' respondent gave no qualification or suggestion, another said 'yes' but difficult as catfish has almost no limits to supply and a large untapped market in the US. Two 'yes' respondents offered redfish=red drum *(Sciaenops ocellatus),* hybrid striped bass *(Morone saxatilis X Morone chrysops)* and white crappie *(Pomoxis annularis).* One said "perhaps" but discounted tilapia and hsb. The problem for a new competitive species is matching catfish production costs.

31. How important are strategic alliances in new product development?

1. Most important as the catfish companies lack funds for research and development. For example the company could easily sell large quantities of redfish (red drum) or hsb if both species were developed at a production cost which enabled a competitive sale price. The company has not the resources to develop a new species like redfish and is therefore dependent on the universities for research and alliances with feed companies. For example Mississippi State University and Delta Western in partnership are developing better feed for better nutrition for catfish. Universities also provide design solutions for farms and processing plants.

2. Most important. The primary strategic alliance in new product development is with a number of key customers that believe in the potential of the new product and will support the supplier. Catfish should consolidate. We have too many fragmented companies, none of which are financially strong enough to do a good job of marketing and new product development. Unlike Tyson (chicken), Hormel & Smithfield (pork), and IBP & Con Agra (beef), catfish has no large successful companies with the capability of large marketing and R & D budgets.

3. Most important, particularly alliances with universities who conduct research and development there. Their partnered feed company has research ponds at their mill for Mississippi State University to try different formulations on catfish.

4. Not important.

5. Not important. If a company is dependent upon particular individuals, it loses ability to sell to others. This company sells to three separate entities in the State of Texas and all three are using company product to compete against the others. Therefore the company always wins. It cannot afford to pick and choose and protect one against the others, but must sell to however will buy, because that will change as different markets open and close wherever the best price is available.

Summary

Importance of strategic alliances

Most important (3) Not important (1).

One 'most important' respondent noted that the primary strategic alliance in new product development is with a number of key customers that believe in the potential of the new product and will support the supplier. Strategic alliances are important because:

1. Research and development. (2). Catfish companies lack funds for research and development and is therefore dependent on the universities for research and alliances with feed companies. For example Mississippi State University and Delta Western are in partnership developing a better feed for catfish. The company could easily sell large quantities of red drum or hsb if both species were developed at a production cost, which

enabled a competitive sale price. Universities also provide design solutions for farms and processing plants.

2. Consolidation. (1). There are too many fragmented catfish companies, none of which are financially strong enough to do a good job of marketing and new product development. For example, Tyson (chicken), Hormel & Smithfield (pork), and IBP & Con Agra (beef). Catfish has no large successful companies with the capability of large marketing and R & D budgets.

Strategic alliances are not important because, if a company is dependent upon particular individuals, it loses ability to sell to others (1). This company sells to three separate entities in the State of Texas and all three are using company product to compete against the others. Therefore the company always wins. It cannot afford to pick and choose and protect one against the others, but must sell to whoever will buy, because that will change as different markets open and close wherever the best price is available.

32. How big an issue are site availability, water value and use for new species development?

1. The three reasons the catfish industry started are; water, plenty of it under the Mississippi Delta and close to the surface (200ft) therefore little energy needed pumping; soil, heavy clay to hold the water on the surface; finance, wealthy farmers with the money to be in the catfish business.

2. Important.

3. Very good water table (70ft) and much cheap land for expansion because grain prices are so low.

4. Water quality is most important and needs constant monitoring twice a week for chloride and nitrate levels and every two hours for oxygen levels.

5. Every decision has to be site specific. Fish need water and the company is located 32 km west of Mobile, Alabama which has the highest rainfall in the USA (208 cm-218 cm rain/year). SeaChick is located in Mississippi because MS is an aquaculture friendly State in terms of the laws and predisposition of the Legislature. The ground water is geothermal artesian and flowing at the surface. For example one company well without a pump flows at 3785 litres of water per minute, no electricity and 31°C every day of the year. The system is single pass (flow through) and located on a river because the pumping requirement is 36,368,000 litres therefore discharge is 36,368,000 litres a day. The water is brackish therefore no other competitors. No human competition (chlorides), no industrial competition (contaminating minerals and salts), no agricultural row crop, surface crop, land based agriculture use for that water (adverse minerals). The water does everything the company needs, is totally unattractive to everybody else, but cannot be discharged into a fresh water stream. The discharge river flows through the Gulf coast of Mississippi into the Gulf of Mexico where the salt-water wedge from the Gulf meets the fresh water making the river already brackish. The next item is liquid oxygen because air has only 20% oxygen it takes a lot of electricity to get oxygen into water. Pure oxygen goes into water very easily and it provides an automatic backup if electricity is lost in a blackout. Oxygen is self-pressurising and provides certainty of keeping the fish alive, even in the most critical of events. The largest supply of liquid oxygen in the United States is between New Orleans and Cape Canaveral, less than 30 minutes from the company. Feed is the single most expensive ingredient and some of the make up of fish food is fishmeal. The largest supply of fishmeal in the United States is located five minutes from the company on the Gulf of Mexico. The coarse grains used to fill out feed formulation, wheat, corn, soybean, milo are produced cheapest in the Mid-Western States of Iowa, Illinois, Kansas, Nebraska and delivered cheapest by barges travelling downstream on the Mississippi River to the Gulf of Mexico. These bulk grains moving to the Gulf of Mexico for export are available inexpensively which is one reason catfish farming has done well in the Mississippi Delta. The company is high tech and uses much electricity to reduce the labour costs. It negotiated an electrical cost of 3 ½ cents US per kilowatt hour, one quarter of what the competition pays around the rest of the country. To avoid hurricanes and floods the company is located 24 km inland from the Gulf, within one quarter of a mile from a power plant. Power comes from two different directions, the normal southern connection and duplication of power from the northern connection. If the southern connection is interrupted the north cuts in giving a double feed system specific to the site. In the worst case the company must generate its own power and is located within16 km of one of the largest refineries on the Gulf Coast of Mexico. During Hurricane George, power was lost when the power station stopped generating; switched from Plan A which is dual feed, use the power company to Plan B, generating electricity on the company's diesel generator. Plan B failed when the wind driven rain got into the generator and shorted out the voltage control circuit. Plan C is a two week supply of liquid oxygen in storage and that takes over immediately when the electricity goes off. Backing that up as feeding had stopped, oxygen was going to the fish, the fish which need water exchanges. The artesian water in a twelve to sixteen hour period started flowing to the tanks by itself. The system is designed so that all the water drains by itself (gravity) without any electricity. These site-specific assets saved all the fish during the hurricane during a 36 hours blackout. Five or six aquaculture companies in the US that went out of business in the last 24 months because they lost electricity for more than three or four hours.

Summary

Site availability, water value and use

All respondents regarded sites and water as important (5) and one stated "every decision made has to be site specific." The three reasons catfish started were water (3), under the Mississippi Delta and close to the surface (200ft) therefore easy pumping (2), soil (2), heavy clay to hold the water on the surface and finance; wealthy farmers with the money to be in the catfish business. Other reasons cited were cheap land (1) available for expansion because of low grain prices. Low grain prices also assisted catfish because cheap grain enables millers to produce cheap feed. Sites must be strategically located to all agribusiness chain inputs as possible.

33. If you were to develop a new species, would you use the same strategy used to develop catfish?

1. It depends on location. With plenty of water below the surface, build ponds, with unpolluted, pure rivers, put in cages. Fit the production system to the species

2. Yes.

3. Catfish wasn't developed like a new species might be, it just evolved. No other species in the development stage to surpass catfish. Fish consumers are familiar with species like bass or crappie, which when enhanced by availability, quality and freshness may be contender new species. Grass carp has potential as a live market fish.

4. Catfish evolved as a generic. There was no strategy development and no one person or group that can take credit for development of catfish. With catfish things were done which are still not really understood, in some cases the industry didn't know what it was doing when developing. Now a new species requires a private label or patent. The developer must have control of the product (species) name and the source of the product. The future is to get out of the generic business.

5. No. Would have spent more time looking at the live market. Hsb serviced the fresh and frozen markets and further processing of fillets, but could not achieve the economies of scale. Going to live production saved a large amount of money reduced staff and cut costs back. Bass has a 2% fingerling survival rate in the wild that can be improved to 98% with human intervention spawning. Because the females would produce so many offspring per spawning, spawning need take place once per year, therefore few brood stock and collection of brood stock once per year as opposed to having to collect them sequentially or throughout the course of the year. This eliminated the need to constantly set up and operate an expensive and labour intensive nursery. The sexual maturity of the species was delayed; for the male it's three years and the female five years. With protracted adolescent pre sexual maturity stage the fish are well fed to increase their weight. Tilapia were avoided initially because they spawn frequent small amounts (three to four weeks), requiring too many broodstock, therefore more labour and constant nursery mode. Tilapia become sexually mature at three months, hence a short adolescent period negating substantial weight increase because their metabolic energy goes into sexual activities rather than putting on weight. Tilapia, because they are mouth brooders have a 90% plus natural survival rate of their fingerlings. Tilapia had few opportunities for intervention to make much of a difference, other than to spend a lot of time and effort trying to get these fish to spawn in sufficient numbers. A Third World technology was adopted by putting the broodstock into fingerling ponds fed chemically to create algal and zooplankton blooms and the ponds feed the fish while the bred. Fingerling cost in hsb fingerlings at ¾ to 1 inch in length were 15-20 cents per fish. 100 gram tilapia stocking fish cost of 2-4 cents per fish, by adopting a Third World as opposed to a First World technology utilising labour extensively rather than intensively. A little labour cared for many fish harvesting only the top fish leaving the other fish behind to keep growing and filling in the spaces of the fish we take off the top.

Hsb was very labour intensive for a short period of time, for the tilapia the ponds were ignored for most of the year to harvest fingerlings and to occasionally rotate the broodstock. Tilapia succeeds *because of the genetic diversity within the populations.* The problem with hsb is the reproduction propagation scheme had too few parents. It's like cloning a forest, one disease comes in and it hits everything which shares the same genetic background. *Mycobacteria marinum* was what caused us to get out of hsb. In tilapia a disease called *Streptocuccus iniae* started to affect our competition. The company dealt with *Streptocuccus iniae* in 1991 by called "competitive exclusion," using a probiotic as opposed to an antibiotic, which fights bad pathogens bacteria with good bacteria that out compete.

Summary

New species strategy

The question elicited a mixed response.

Yes (1), No (1), Depends on location (1) Catfish evolved without a strategy (2).

The yes answer was unqualified. The no answer was qualified by the observation that the live market is the future and any strategy for new species development must include delivery and customer purchases of live fish. Demonstrating a 22nd Century standard grasp of value chain operations during interview and unconstrained by set streams of technology, he would examine bundling up a range of technologies from various stages in the evolution of aquaculture, observing not all solutions come from modern technology. The respondent who answered location, qualified it by specifying if the location has ample ground water, develop a species suited to pond culture; if the location has unpolluted, pure rivers, develop a species suited to cages, thereby fitting the production system to the species. One of the two respondent's who said catfish evolved, alluded to the importance of location by referring to different species growing differently in the production environment (catfish and grass carp) and then sold to different markets, for example live grass carp and processed catfish. A recurring theme in all the interviews is that catfish was not developed like a new species might be, it evolved as a generic (2). One noted that no strategy initiated development of catfish and not one person or one group can take credit for development of catfish. This person observed that in catfish development things were done which are still not really understood, in some cases the industry didn't know what it was doing when developing. He further stated the future is to get out of the generic business, a new species requires a private label or patent and the future developer must have control of the product (species) name and the source of the product (1). There are no other species in the development stage to surpass catfish, but consumers are familiar with species like bass or crappie, which, when enhanced by availability, quality and freshness may be contender new species. Grass carp may have potential as a live market fish.

34. How important were governments in establishing your industry?

1. Not important, other than the provision of money (grants and loans) for farmers and processing plants. The industry employs low wage people who may otherwise not have a job. The government provided no money for marketing and marketing infrastructure itself.

2. Important. Mississippi, Alabama, Louisiana, Arkansas and Georgia are supportive of new industries that provide employment. Their regulatory agencies, environment, wastewater, site selection, work with, for example a processing plant developer in a "partnership" role, not an adversarial one. Catfish received no government assistance other than a limited amount of government backed loans for the building of processing plants. This firm never had government assistance. Growth was financed through company profits.

3. Not important, the industry did it with the Catfish Institute. Feed mills donate $5 for every ton sold to the Catfish Institute, thereby raising $3-$4 million. The Institute employs a New York advertising firm to programme the best way to expand our industry using a check off for advertising and promotion. One method is via publications magazines read by women read and seafood buyers. The Government is a problem now by promoting free trade with countries and exporting US high technology into low waged countries who then manufacture for the US market, without safety departments, EPA, health insurance and many of the US taxes we have to pay. Therefore the goods are cheaper and this applies to Vietnamese catfish, allowed in by the government. The government is helping combat the Viet Namese catfish because this region is the poorest part of the US and its (catfish) is probably one of the only industries that's done well for the poor people in creating jobs for uneducated disadvantaged people. Help hasn't come from the FDA but will probably going to come from some bills being introduced requiring it to be called basa and not catfish then we compete with ours as catfish and theirs basa which is fair competition.

4. Incidental. In one case deliberately and in the other incidentally. The catfish spawning habits researched by a university because the Government wanted to replenish wild stocks. A university made a difference in feed by discovering that the protein level couldn't be distinguished just by percentage alone. The miller had to know what proteins to put into feed, which was a break through. Then somebody came up with the idea of making the feed float so what the fish were eating could be seen. There were a whole series of little incidents that made it viable.

5. Clearly important. The company fronted the State legislature in Mississippi and said and requested an aquaculture law. Catfish was not considered aquaculture, it was considered farming. By going in front of the legislature the important language *aquaculture is agriculture* was established. Without that language the State of Mississippi was unattractive to the company, but with it came all the agricultural provisions and protections. The local tax authority of the County wanted to tax the inventory of live fish. It was akin to taxing live trees in the forest or the inventory of live grain in the field and therefore not applied.

Summary

Importance of governments

Governments important (2) Governments unimportant (2) Governments incidental (1).

The State Governments of Mississippi, Alabama, Louisiana, Arkansas and Georgia are supportive of new industries that provide employment. Their regulatory agencies, environment, wastewater, site selection, work with developers in a partnership role rather than an adversarial role. Catfish has received no government assistance other than a limited amount of government backed loans for the building of processing plants. This matched a response stating governments were unimportant other than for the provision of money for farmers and processing plants because the industry employs low wage people who may otherwise not have a job. The government provided no money for marketing and marketing infrastructure itself. Because catfish was considered farming and not aquaculture, the other "important" respondent approached the State Government of Mississippi requesting aquaculture is recognised as agriculture. This qualified aquaculture of species other than catfish for the language and enabling legislation of agriculture, thereby applying agricultural provisions and protections to aquaculture. The other "not important" respondent said the industry developed itself without government but with the Catfish Institute. Feed mills donate $5 for every ton sold to the Catfish Institute, raising $3-$4 million annually and employs a New York advertising firm to programme the best way to expand the industry using a check off for advertising and promotion. However the Government has an important role protecting catfish against Viet Namese catfish imports because the industry is located in the poorest part of the US and is probably one of the only industries that's done well in creating jobs for uneducated, disadvantaged people.

The "incidental" respondent credited the government with deliberately assisting universities to research catfish spawning habits to replenish wild stocks. This helped establish catfish and led to incidental improvements making catfish viable. A university made a difference in feed by discovering that the protein level couldn't be distinguished just by percentage alone; the miller had to know what proteins to put into feed, which was a break through.

Environment

35. When establishing, how did the catfish industry cope with environmental issues?

1. When establishing, there were few laws, the South was relatively environmentally clean and the environmental movement had not started in the region. The environment (climate and water supply) is right in the South for catfish aquaculture. There are very few other places in the United States where catfish can be produced as well as in the Mississippi Delta. The catfish is an almost prehistoric fish and is immune to about all the diseases other fish catch. He's extremely tough so doesn't need a lot of chemicals and the only pollution in the water is faeces going in the water, a kind of natural fertiliser. If the industry used a lot of chemicals and then discharged them into a stream or a river there would be problems.

2. As the industry developed and as processing plants were planned and built, the industry had to conform to each state's regulations concerning waste water affluent and solid waste (catfish by-products) disposal regulations. None of these were serious impediments to the development of the industry. We now have over thirty catfish processing plants in the U.S.

3. There were no environmental issues and no problems with the EPA over ponds. Permits are required for wells, but not ponds, nor are permits required for dumping ponds or overflow ponds, however processing plants need permits as their ponds, in a lagoon system break down plant by products of blood and fat.

4. There were few environmental issues. Now the EPA is looking at several items but the effluents leaving the pond are really not as bad as the effluents already existing in a lot of streams. The ponds are settling areas. The effluent decomposes in the pond itself and not going into public waters. Ponds are environmentally different from cage production systems.

5. Same strategy, go to the Government describe what you are going to do. We have battled with our local State and Federal Government on our discharge because we are single pass flow through system. We battled them and battled them and then we won because we demonstrated that live fish have a water discharge which also allows live fish to live in the discharge. We don't accumulate and concentrate waste. We actually take the waste out of the water before we discharge it and grow another population of fish with it. We call that *sequential polyculture.* So instead of using a microbiological solution to cleaning up water like most wastewater treatment plants do, using bacteria and mechanical and electrical means, we use a natural means which is a live population of fish to filter our water. We use a high level organism instead of a low level organism and we get to sell the high level organism for profit and it costs us nothing to feed it
The water in which or fish grow has no pollution, it last fell as rain about 20,000 years ago. Tilapia is grown using no antibiotics, no hormones (neither growth, nor sex reversing), no genetically modified fish and no fish meal. It's unconscionable to take food from the ocean and waste it on growing fish under aquaculture conditions.

Summary

Environmental issues when establishing

All respondents agreed that when establishing, there were few laws, the South was relatively environmentally clean and the environmental movement had not started in the region (5). Because catfish is so tough it doesn't need a lot of chemicals and the only pollution in the water is faeces, a natural fertiliser (1). There were no environmental issues and no problems with the EPA over ponds. Permits are required for wells, but not ponds, nor are permits required for dumping ponds or overflow ponds, however processing plants need permits as their ponds, in a lagoon system break down plant by products of blood and fat. The EPA is looking at several items but the effluents leaving the pond are really not as bad as the effluents already existing in a lot of streams. The ponds are settling areas; the effluent decomposes in the pond itself and not going into public waters. Ponds are environmentally different from cage production systems.
One respondent noted that as catfish developed and processing plants planned and built, the industry had to conform to each state's regulations concerning waste water affluent and solid waste (catfish by-products) disposal regulations. None of these were serious impediments to the development of the industry. There now are over thirty catfish processing plants in the U.S.

36. How would you now develop a new species taking into consideration contemporary environmental issues?

1. Recently the Environmental Protection Agency has tried to regulate catfish farming, aquaculture in general and waste water. In Mississippi a farmer drains his pond into his soybean field or lets it run down the drain. Though the EPA tries to prove otherwise, catfish aquaculture is not an environmental hazard and the industry should be exempt regulations imported from other parts of the country. Predatory birds, like crane, heron and cormorants which were once shot, now have regulations on their treatment. Catfish is a hardy species and immune to most diseases, negating the need for most chemicals. The only water pollution is faeces, a natural fertiliser.

2. Development of a new aquaculture species would not pose any major environmental problems.

3. Comply with the contemporary regulations

4. Grow an herbivorous new species in a pond or flow through environment so the out flow can be controlled. Blue fin tuna (in Australia) should be raised on vegetable products if possible, though feeding it on a sustainable trash fish is probably OK, but people are concerned about using fish to feed fish. A carnivorous fish cannot be supported either environmentally or economically.

5. The same way. The majority if not almost exclusive use of methyl testosterone to reverse the sex of tilapia females to make an all male population will not fly with the Oriental population. Once they understand that issue they will never eat tilapia again. People are getting very nervous about genetically modified fish. Fishmeal itself has the problem of the possibility of mad cow disease syndrome, so you've got all kinds of issues that make no sense whatsoever to go down that path. That is why we are in a field by ourselves where stipulated these things on a website. We are the only people growing fish in an ecologically sound manner. We will not claim we are growing the fish naturally. What we say instead is we grow the fish in an optimised environment. We let the fish tell us when we've achieved the optimum environment. We call it environmentally controlled housing for fish.

Summary

Establishing with contemporary environmental issues

In answering the question, "how would you now develop a new species taking into consideration contemporary environmental issues," two respondents specified the new species must be herbivorous. Both were emphatic in their responses.
"A carnivorous fish cannot be supported either environmentally or economically." (1). "It is unconscionable to take food from the ocean and waste it on growing fish under aquaculture conditions." (1). The new species should be grown in a pond or flow through environment so the out flow can be controlled. Another respondent said development of a new aquaculture species would not pose any major environmental problems and one other would simply comply with the contemporary regulations

The Environmental Protection Agency according to one respondent has tried to regulate catfish farming, aquaculture in general and waste water. Though the EPA tries to prove otherwise, catfish aquaculture is not an environmental hazard and the industry should be exempt regulations imported from other parts of the country. Predatory birds, like crane, heron and cormorants that were once shot, now have regulations on their treatment.

Catfish is a hardy species and immune to most diseases, negating the need for most chemicals. The only water pollution is faeces, a natural fertiliser. One respondent said consult the Government and describe what you are going to do. His company battled with Local, State and Federal Government over wastewater discharge and demonstrated that live fish have a water discharge, which also allows live fish to live in the discharge. The company does not accumulate and concentrate waste, it removes waste from the water before discharge and grows another population of fish with it, calling the process sequential polyculture. So instead of using a microbiological solution to cleaning up water like most wastewater treatment plants do, using bacteria and mechanical and electrical means, the company uses a natural means which is a live population of fish to filter our water. They use a high level organism instead of a low-level organism and we get to sell the high level organism for profit and it costs us nothing to feed it. The water in which or fish grow has no pollution, it last fell as rain about 20,000 years ago. Tilapia is grown using no antibiotics, no hormones (neither growth, nor sex reversing), no genetically modified fish and no fishmeal. The same respondent cautioned that if Oriental consumers discover use of methyl testosterone to reverse the sex of tilapia females to make an all-male population they would never eat tilapia again. He also cautioned that people are worried about genetically modified fish and fishmeal itself has the problem of the possibility of mad cow disease syndrome. His company does not claim to grow the fish naturally, but grows them in an ecologically sound manner in an optimised environment, letting the fish indicate when the optimum environment is achieved, and calling it environmentally controlled housing for fish!

APPENDIX THREE

SALMON RESULTS

Beyond 40° South is no law, beyond 50° South, no God

(19th Century Whalers saying)

Introduction

The interviews were conducted face-to-face during February 2002 in northern, central and southern Tasmania. The interviews lasted from between one and two hours depending on respondents' available time and elicited responses from seven salmon industry players. In one case two players from the one company were interviewed at the same time. Those interviewed were a managing director, hatchery manager, research and development manager, export manager, operations manager, vertically integrated farmer and an aquaculture manager.

Results follow the questions in numerical order and the responses are rated and summarised under abbreviations of the questions. Where relevant, response frequency is recorded immediately after the questions followed by brief explanations based entirely on the respondents' words. In some cases, respondents provided answers to survey questions in areas of the interview other than in response to the question being asked.

Catfish industry survey data revealed the importance of industry leaders in developing new species. Hence the question; how do you see the role of industry leaders in developing new species was added as an appendage to question 9; "How do you see the role of a product champion in developing a new product?" Question 9a was subsequently applied to the salmon and barramundi industries.

Survey questions

New product ideas

1. How do you define a new aquaculture species?

1. A species yet to be successfully commercially produced

2. A fish that may or may not have a traditional capture fisheries market which hasn't been cultured intensively or extensively before.

3. An arbitrary and artificial definition in the Australian context for a new species is one that reaches $10 million revenue. Before that it's in the pioneering stage and not an established aquaculture species.

4. A species still in the development phase, which has not generated any operating profits.

5. There are two stages of newness, new to the world and new to Australia. For example farmed salmon and barramundi are not new to the world, but new to Australia. A new species is new in the world. Transferring and adapting information on an existing species from another country to Australia developed salmon aquaculture in Australia.

6. A new species is a new product line whether a different species altogether or a species in the same family group as those in culture. Many of the management regimes needed to cope with aquaculture species are generic.

Summary

Definition of a new species

Perception of newness varied, resulting in a hierarchy of responses defining a new species as; not previously commercially cultivated; still in the development (pioneering) phase without operating profits; yet to be commercially produced; new to the world or new to Australia; arbitrarily and artificially defined (in the Australian context) as one that reaches 10 million dollars revenue or a new product line.

2. *Where do ideas come from for new aquaculture species and their products?*

1. Someone thought it was a good idea, a politician, a well-meaning academic, and not necessarily a marine biologist. Then marine biologists from aquaculture institutions are given a mandate to research the new species.

2. Ideas come from fisheries science research for the new species and the food industry for the processed, value added derivative new products from the species.

3. Anywhere

4. Market pull and biologists and aquaculturists who think they've seen a niche.

5. The market where a species has a high price but lacks supplies, causing people to think about farming it, for example abalone. The idea may also come from the production end of the chain. If a species is easy to farm, developers may think about making it acceptable to the market, for example catfish.

6. Market. The company both grows and catches fish so ideas come from wild fishery trends (pressures, continuity of supply) which indicate species in demand in the market. Then analyse the ability of aquacultured species to fill that gap.

Summary

Origins of general ideas for new species and products

Market (3), Aquaculturalists (fish farmers) (2), Fisheries scientists (2), Politicians (1) Academics other than marine biologists (1).

Ideas come from the market; fish farmers' and fisheries science research for the new species and directly from the food industry (as a separate industry) for the processed, value added derivative new products from the species. The supply><demand equation is high priced species in short supply which is thought to be easy to farm. The species then becomes the subject of a desktop review.

3. Where would you get ideas for new species and new products?

1. A well-known species with wide market appeal. For example sea bass or sea bream, snapper and barramundi are ubiquitous and sold on the world market.
Then by a process of reduction, matching the species to its geographical/ environmental parameters and conditions for aquaculture. In the early growth stages the ideal marine species is fecund with large egg size, without transition problems when moving from very small fry or from *Brachionis/Artemia* to the next food.

2. Market demand, fisheries scientists aren't necessarily the best people to develop a new species or come up with the ideas

3. Aquaculture players for the species and marketers for species' products or someone outside the industry with resources in either field.

4. The market for acceptability and price sensitivity, then correct geographical conditions, where water temperatures in sites suit the species, if not investigate re-circulation or intensive technology and balance increased cost of production against the cost of marketing.

5. Identify gaps in the market, which in Australia indicate a market for a good lower priced white fish, ideally not reliant on expensive fishmeal. It's easier to observe developments overseas, see what works and transfer it into Australia, for example salmon or sea bass than starting a new species in Australia which is difficult from scratch.

6. Examine the market requirement and the ability of a producer to maintain continuity of supply of the chosen species at a price above $10 kilo end-selling price. The postulated early returns are attractive and ideas abound. For example returns on live shipments to Japan. The developer must look beyond this optimism at the type and characteristics of fish consumers want and the market demographics because the market may be semi developed. For example white flesh, coloured flesh, value adding, preparation requirements, all year round supply, can the fish be frozen and still be good quality and will it meet a price point?

Summary

Sources for individual ideas for new species and products

Deliberately seeking ideas is the first stage of the new product development process and again the market is dominant (6), aquaculture industry (1), fish suited to geographical location (2), known species (1), entrepreneurs (1).

Ideally the new species fits well-defined environmental parameters and is not reliant on expensive fishmeal. If water temperatures do not fit investigate re-circulation. Importing technology from overseas is easier than developing a species in Australia from scratch. Market criteria are flesh colour, potential for value adding, preparation requirements, ability to freeze, year round supply and price.

4. How would you appraise those ideas for new species?

1. By examining its biological attributes for aquaculture. Shoaling fish? Live at high densities? Adapt to pellet feed? Can feed be produced economically? Good egg size? Hatchery issues resolved? These interlock market appeal and cost of production.

2. Existing market, product volume and value within that market. Existing high value niche and local markets have been saturated rapidly by new aquaculture ventures. For example when sea bass and sea bream in Europe achieved 20,000 tonnes, the price structure struggled because the market was saturated and insufficient new markets were generated for the product. Subsequently new markets were developed.

3. Evaluate why, when and where.

4. Market price. Acceptability. Niche. High value at the start to cover development costs. Profit in the early days before production increases and profits decline.

Species physiological characteristics. Geographic suitability, latitude best grown or re-circulation. History of cultivation to assess feasibility. How cost of production fits with market prices, then model that forward. How will the market react to increased volume? Is the price going to drop? Halibut market prices were dictated by wild catch. Market price went up in winter when it was stormy and the fishermen couldn't get out. Aquaculture production evens out peaks and troughs and settles at a level, therefore care when picking sale price level. Initial small volumes=high price, bigger volumes=lowering price, therefore price point is crucial for market pitch.

5. Analyse the temperature profile of the selected fish. Australia's competitive advantage is in growing a fish in cooler rather than warmer waters because of low labour costs in warmer waters, allowing cheap production of fish. Higher priced labour happens in cooler waters, for example Scotland and Norway, with Chile the exception. A species grown in warmer Australian waters must be able to compete with species grown in warmer waters of low cost of production Asian countries. An herbivore is ideal, but a carnivore would not be ruled out. The species should grow fast be cheap to grow and give a *unique advantage* that other players could not readily replicate.

6. Desk top review, to ascertain available technology and knowledge for the species. Closed lifecycle otherwise wild stocks are needed for recruitment placing the developer in no better position than wild caught. If the lifecycle is not closed, how far away is closure. Adaptability of the species to farming, market demand, the ability of a competitor in the short term to replicate the development and the possibility of substitution in the market of a similar but cheaper species in the market. Species lifecycle or how long the species must stay in the water and therefore the financial risk profile. Is the species well known, will it receive immediate support in the market or does it need market development?

Summary

Idea appraisal for new species

Market (3) Biological/physiological attributes (2) Cost of production (2) Geographic location (2), Ability of a competitor to replicate (2), Uniqueness (1).

Respondents all indicated knowledge of the desk top review concept and related potential market performance to cost of production and the supply/demand curve.

The new species should be a unique herbivore readily adaptable to domestication that delivers a sustained performance in the agribusiness value chain and is difficult to replicate. Modelling market reaction and developing new markets to cope with increased volume is important with models from sea bass, sea bream and halibut available for application. One company had undergone a semi formal study evaluating ideas for new species under the headings of why, when and where.

5. What sort of organisation is likely to develop a new species?

1. The large research component necessary before industry uptake requires a research facility to develop the species with industry. For example nutrition research takes generations of trial and error, adaptation, sampling and fine-tuning. Feed is 55%-60% of production cost therefore partnership with a feed company and university is appropriate as happened in Tasmania with the salmonid industry.

2. A government fisheries organisation for the biological work and large multi national agribusiness firms with strong R&D components or a feed company.

3. One with the resources and will for a venture, but the pioneering work is often done by individuals. The driver is important.

4. Historically government sponsored laboratories for initial broodstock and generating interest then handing it to the private sector for development. Existing aquaculture operations of which there are two types, bigger companies who, through their scale can afford small new development sections. For example Nutreco's cod hatchery in Norway. Money from core operations (salmon and salmon feed) is invested in new species at a late stage in the development, a few years commercial feasibility. Then pioneer owner operators who try and attract investors, for example Alistair Barge at Otter Ferry in Scotland (halibut) and Paul West and Richard Slaski at Mannin Sea Farms in Great Britain (turbot). Their vision and enthusiasm enables success. Feed companies won't put development into the feed until they think it's going to be commercial.
In new species development the available diets for sea bass, sea bream, turbot, halibut, salmon, tuna are close enough before fine tuning diet development. Diet development is aided by observing what the species eats in the wild.

5. Ideally an existing aquaculture operation with infrastructure, fixed overheads equipment, experience and cash flow to support and observe the experimental phase of the new species before larger investment. A company on a budget of $250,000-$500,000 set up to develop a species to the point where a larger commercial operator could take over, similar to mining operations where small companies drill for oil and if successful sell the results to a larger company.

6. Research institutions (universities) act as catalysts for entrepreneurs to consider the opportunity. Development work is expensive in time and money. Commercial players are limited by their ability to uptake every idea. Researchers' liasing with commercial operators are able to discuss problems at stage gates and find solutions because the operators are dealing with practical issues every day and know how to get around them.

Summary

Organisations to develop a new species

Co-operative partnerships or strategic alliances between existing producers from pioneer operators to agribusiness companies which may also be feed companies, and research institutions, allowing cross referencing of science with practical solutions business reality and nutrition, are the combination most likely to develop a new species. Research institutions act as catalysts for entrepreneurial thinking but must liase with commercial operators to balance scientific thinking with commercial reality.
Few commercial operations have the time money and patience to do the development work, though some can be deliberately set up to initiate research and development, then selling the results at the stage of commercialisation.

6. Is your organisation structured to develop a new species?

1. No. Company is in the formative years focussing on core business first. Future opportunity is working with a research institution looking at new species opportunities particularly a white fish to complement the red fish with production synergies.

2. Yes. The organisation was set up to develop Atlantic salmon as a new species, but with no consideration for developing other salmonids let alone other species.

3. Yes.

4. No, but has the capability and would look at new species close to commercialisation. Currently restricted by the salmon situation. Better cash flows would enable more resource input to new species development. Company grows some rainbow trout in the sea (ocean trout) which are difficult to sell in a competitive market. Possibly interested in on growing yellowtail kingfish in South Australia from SA hatcheries with experienced staff from the company.

5. No.

6. No, the company lacks the size, but has the personnel, technical expertise; the ability to farm, market and assess the processors to analyse options.

Summary

Organisation structured to develop a new species

No (4), Yes (2).

Though three companies answered "no," two indicated they had the expertise if not the financial resource to develop a new species. The hatchery was specifically set up to develop Atlantic salmon and could develop another species.

7. Is your organisation currently investigating a new species?

1. No, but has a partnership with a research organisation which delivers; a teaching facility, a facility with filtered water at constant temperature for a marine fin fish hatchery, both of which can dovetail with the company's commercial operation for development work. Potential new species for the partnership are yellowtail king fish (Tamar might be too brackish), snapper (which occur in the Tamar), black bream *(Acanthopagrus butcheri* Munro 1949) and flounder. With industry and a training provider working together Federal funds may be accessed. Snapper up to 15 kilo occur in the Tamar between Beauty Point and four kilometres upstream from the site. Snapper like the environment but are out of their normal geographic parameters and temperature range of around 14°-27° C and lower salinity. Snapper may not grow in the cool Tamar winter but would consume less feed, avoid disease problems and grow well at other times of the year. The Tamar was thought too warm for salmon, yet they do well, with no seal problem and no net fouling problem (high energy site) and no amoebic gill disease, a parasite in the gills which adds a huge cost to production.

2. No, but watching developments in salmon, looking at company technology and the potential for other species if there was a reduction in demand for our existing species. Need to continually get value from the asset and recently invested in re-circulation technology allowing culture of almost any freshwater species.

3. Yes. Striped trumpeter and rock lobster.

4. No, but remaining aware and keeping abreast of developments.

5. No. Still in the process of fine tuning salmon and trout.

6. Yes, nothing specific but always looking to develop something.

Summary

Organisation investigating a new species

Yes (3), No (3).

One "no" respondent has organised a co-operative alliance with a research institution that owns a facility capable of being utilised as a marine hatchery.
The respondent identified yellowtail kingfish *(Seriola lalandi* Valenciennes 1833), snapper, bream and flounder as potential new species, noting that their site is not in snapper's optimum temperature and salinity range. The other "no" has scanned the environment and equipped its hatchery for a range of new species options. The "yes" respondents identified striped trumpeter, rock lobster and *anything* that may appear!
A new species may be suitable for a site without meeting all biological requirements.

8. How would you specify the design of a new product; what does a new product or species have to do?

1. Grow quickly, good FCRs with appropriate diet development, low mortality rates, low reject rates and a disease free operation avoiding chemicals and antibiotics.
Once cultured, market appeal and readily marketable in a mass market with very large volumes or a niche market at the gourmet end of the scale with smaller volumes.
Presentation is important, for example catfish is an unattractive fish. Therefore it's sold as fillets which look acceptable. Aquaculture enhances the quality of a wild species by fulfilling its dietary requirements with trace elements and vitamins delivering a complete diet to produce a perfect animal and eliminating seasonal variation.

2. It must be technically feasible and able to serve an existing market, either high value or high volume, but capable of absorbing increasing production from aquaculture.
Rock lobster has an existing high value market with strong demand and no evidence of market saturation. The prices are achievable and the wild stocks are in decline, but the length of its larval stage is a technical problem which questions its suitability as a new species. Many business plans suggest profitability after five and up to 10 years operation, but a bank or investor must see the product generating cash flow within two or three years, to demonstrate its feasibility, whether initially profitable or not.
A product's visual appeal is important. For example market research claims the Japanese love the look of striped trumpeter with its beautiful stripes and its derivative products

make nice sashimi. *An aquaculture product should achieve market size within a two to three year time frame.*

3. Be attractive. For example, the Japanese perceive barramundi as unattractive therefore barramundi is better presented in fillet form. The "marginal edge factor."

4. Consumer acceptance, good market value and a feasible 2-3 year time scale for economic production, but no longer than 4 years.

5. Easy to farm, robust, disease resistant, unlikely to suddenly die and produced at a cost the market can absorb. The product either needs to fill a gap in the market or the developer needs to create a market. Either there is an existing spot for the fish requiring very little marketing, just supplying into an existing vacuum or an image must be created around the new species which is sometimes a new marketing name. For example ocean trout is an invented name marketed in food magazines during the late 1980's, gradually becoming an accepted name. It's just a trout in the sea. The real name of a new species might not suit the market, so a marketing name may be created.

6. Initially as background; broodstock security, closed lifecycle and a safe reliable environment in which to grow the fish. The fish's lifecycle will determine the level of risk and the return required on the species. A species grown in two years might require a different level of return on your investment than a species that takes five or six years to maturity and market. Cost of farming is tied to feed conversion rate and in most species is a key indicator to the total cost of the fish. The market may not demand a year round supply, but if the market requires it, a technical assessment needs to assess the producers' ability to service the market as the market requires. Some species don't require an all year round presence. The can be a cultural linkage where consumers think it's strange when a species is in the market when it shouldn't (naturally) be in the market. There is a perception that if the market is under supplied, an aquacultured fish, plugging the gap can achieve a high price. The question is what price can the producer achieve supplying the market each and every day. Regular prices can be significantly different from spot prices. What is a realistic ongoing return the producer can expect? Beating the competition to the market can make money, so can an aquacultured fish that satisfies demand better than existing product. The delivered product needs a sustainable competitive advantage.

Summary

New product design

The design of the agribusiness value chain to enhance species' physiological characteristics is more important than design of the species itself. The chain operation and the species performance within it should deliver a 2-3 year growth cycle, detailed diet development, good FCR's, robustness, no disease and low mortality, grown in a safe reliable environment. In the market it must be readily accepted, attractive and marketable in a mass market with very large volumes or a niche market at the gourmet end of the scale with smaller volumes.

Derivative products from the species are designed by market signals received through the chain detailing specifications of, or modifications to the new product. Presentation is important, for example the Japanese see barramundi as unattractive, so it is better presented as fillets. Market research claims the Japanese love the look of striped trumpeter with its beautiful stripes, derivative products from which make attractive sashimi. Catfish is an unattractive fish therefore it's sold as fillets which look acceptable.

If the product fulfils the production requirements but has no market, one is created to satisfy the previous criteria and develop an image which may include a marketing name. A new product if so designed must maintain a year round market presence though some species, for biological reasons cannot, and for cultural reasons will not be available daily. The new product must have a sustainable competitive advantage.

9. How do you see the role of a product champion in developing a new product?

1. Important for a new product in a new market, particularly if a species is not commercially known, but not a known species like snapper or barramundi.

2. Important. With existing demand and technical questions solved, two phases, initially a technical champion for production, an existing market negates the need for a product champion. If an existing market is saturated requiring new market development then there is a role for a product champion with some vision and "go" to develop it. Marketing specialists don't have ownership of the product and are appointed on past performance not necessarily on their ability to generate future performance. A product champion must understand the product and what can be done with the product.

3. Important because somebody must have responsibility for the new product.

4. Not important. In Europe, there's been a history of failure with product champions. A quality image, consistency of supply and clean and green, like Tasmania is more important. Halibut in Scotland is called Scottish halibut from crystal clear waters on the West Coast of Scotland, but the driver was quality not the tag. *The issue is strategic marketing.* The consumers liked halibut, it's a rare, expensive fish indicating a quality, niche product without a massive market because of the value and cost.
Because it was technically difficult, halibut achieved market penetration by slowly gearing up production and releasing small amounts to quality outlets thereby keeping the price up and building up consistent supply. Now halibut is always part of the mix of fish available in UK supermarkets. There was no product champion. Labels differentiate between Scottish and Norwegian halibut with little effect. Quality is most important.

Like striped trumpeter, Atlantic halibut went through a long unsuccessful period of 10 years with governments and academic institutions trying to grow it. People questioned its potential. It got through on some success and a couple of people who could see its possibilities, pushed it and managed it to a stage where there was just enough to keep the inertia going. The industry in Britain was concerned about continuing government support and worried it may pull out of assisting some of the development because enough had gone in. Players had to work hard to keep the Government interested and contributing. The individuals involved had faith even though they could see there had been problems. There was enough there for to see that if everything was right it could still work. They believed in the product that's what kept halibut going. It was a high value good quality fish; *white flesh, no bones very meaty.* The Pacific halibut is softer.

5. Very important. A product champion is somebody who puts the money up for development, takes the risk and expects the rewards. However all parties, entrepreneurs, scientists and marketers have to work together to persevere and make it happen.

6. Very important. Nothing progresses without a product champion and 9 out of 10 a species won't succeed without a champion of their development. Champions inspire others in the equation and 90% are businessmen. They might not have all the puzzle pieces but will have the most important ingredient to get the project started and running and knowledge of and ability to perform required normal business practices. In Australia there are a few ventures showing signs of viability. One or two people will have toiled for 10-15 years probably without the financial resources, which is why it's taken them so long. But on very tight resources they've gained a better understanding of the issues and hurdles. If people have money they might not think through all the issues. Without the financial resources developers discover the problems.

Summary

Product champions

Important (3), Very important (2), Not important (1).

Product champions are important if the product or species is unknown. Product champions are divided into two groups or two functions, technical or biological champions and marketing champions. Product champions inspire other players and 90% are businessmen who take risks and expect rewards. Product success is the result of the convergent activities of entrepreneurs, scientists and marketers working together and persevering to make it happen. The respondent who replied "not important" gave examples of product champion failures in Europe then described a type of champion also identified by one of the "very important" respondents. These champions lack the colour associated with the word champion but are often under resourced owner operators whose determination and enthusiasm over many years leads to success.

9a. How do you see the role of industry leaders in developing new species?

1. Very important. Industry must have the courage to develop new species and leaders need back up from research institutions. A leader's role is not the research but to pick up and commercialise what research has identified. The industry leader would direct the product champion to become the executive officer of the product.

2. Important. An industry leader can be a product champion for an existing product, but not always for a new product. The principals of big aquaculture companies are often accountants and economists, not appointed for their enthusiasm about the specific product or the product vision. They are financial managers and may not understand a new product and better at running existing viable businesses, or turning around performance by examining cost and implementing business efficiencies, to assist the new product.

3. Very important. For example the history of striped trumpeter's development. There was a balancing act between supporters and opponents. The market demands a new white fleshed product and an industry leader's backing of striped trumpeter would help.

4. Very important. If successful with one species industry leaders backing has a powerful influence on new species, diffusing confidence to governments, regulators and the market whilst encouraging uptake by potential producers. The timing of leaders' involvement is important and backing a new species with a public relations campaign before it looks like being successful can damage its development. Therefore leaders should only back winners. For example, halibut's launch was very successful and everyone wanted the product but insufficient fish was available which damaged the industry for some years.

5. Important. Selection of new species must fit water temperature profiles. A warm water fish is Queensland, New South Wales or Western Australia and a cool water fish is Tasmania so leaders need to be consulted in those regions on the viability and profitability of the species. The margin should be 20% to 30% to offset the risk of fish death and disaster.

6. Important. Their role is to set the environment that attracts people to new species development whether it's investment, educational incentives into an area or a co-ordinated approach to market research. After that market forces should dictate, as it can be very dangerous to have a dominant player there who runs the show.

Summary

Industry leaders

Very important (3), Important (2).

The role of an industry leader ranges from regional identification of site locations to diffusing support and influence at government level for a new species. The leader would direct the product champion to become the executive officer of the product. Leaders are seen as courageous but requiring back up from research institutions. Their role is to set the educational, investment and marketing environment for new species development, then allow market forces to take over. A leader should attempt to be a dominant player and be careful to only support winners as their support for a failure may damage a (failed) new species chance at a second go. For example, striped trumpeter would have benefited from the support of an industry leader.

New product screening

10. What should be the selection criteria for a new species?

1. Find out what the market wants and work back narrowing down a species from the broadest possible biological, commercial and market parameters. Then within a defined environment, determine the species suitability to the site's geographical location and match the species that has the appropriate attributes to that environment. Grow quickly, good FCRs with appropriate diet development, preferably not carnivorous, low mortality rates, low reject rates and a disease free operation avoiding chemicals and antibiotics. Once produced, mass market appeal with multiple carcass use, readily marketable in with either large volumes in a mass market or a niche market at the gourmet end with smaller volumes. In culture the species wild environment need not necessarily be replicated. For example in an aquarium most saltwater species survive and thrive at 28 ppt, take it to full salt 35 ppt they struggle to survive.

2. A species with a multiple carcass use, able to be grown under aquaculture conditions to maturity within an acceptable time frame to supply an existing, valuable market with the capacity to absorb an increased supply of fish. A fish cannot be grown and pushed onto the market, particularly white fleshed because white species are subject to supply and demand boom/bust fluctuations of the fishery.

3. Market demand is the priority. Species, which pass selection criteria, will have met on aggregate the following three basic criteria where a deficiency in one may be compensated for by the others. Enough knowledge of the species biology is available to enable some control over their growth and life cycle. A profitable market is identified or developed for the product generated by the species aquaculture. A *marginal edge factor* will have been identified and exploited by the aquaculture operators. This factor will vary and may include localised access to favourable growing conditions.

For example, unpolluted water or an optimal temperature regime. Access to the by-product of another industry, for example, using salt production ponds for flounder culture, or horizontal/vertical integration with a company capable of better utilisation of its resources and skill base.

Development is divided into three stages; the pioneering stage, exciting but with a large cash deficit, the entrepreneurial stage varying between financial boom and bust, followed by the agribusiness stage of market advantage and profitability.

4. Market preference and acceptability. Economically produced in an environmentally acceptable way. Ten years ago it was economics, market acceptability and preference, now environmental considerations rate highly with any new species as they are with the existing aquaculture species.

5. Good culinary presentation preferably with a unique taste, something different, can be recognised and not be substituted easily. Highly desirable in the market and easy to grow in the available environment and not marginal in that environment. For example if the species requires a temperature range of 12-18°C to grow and the site water temperature is 11°C, the site is inadequate. The site must be well within the species ideal salinity and temperature range. One reason is that if a competitor decides to set an operation within the range the new species is just without, viability is difficult.
Ideally a good fish would have a short cycle time.

6. Market appeal, uniqueness, novelty and qualities people cannot duplicate readily with another species. Secure brood stock, closed lifecycle, environment, production, marketing, cold chain able to be organised. Not carnivorous, able to use grain and meal substitutes. Able to achieve first mover advantage.

Summary

New product screening criteria

Market demand (6), Adaptability to aquaculture (4), Multiple carcass use (2) Uniqueness (2), Not carnivorous (2), Species not readily duplicated (2), Environmentally acceptable production (3), Short growth cycle time (1), Geographically suited to, and not marginal in chosen growing environment (1).

There are three basic criteria of which market demand is dominant. The other two are knowledge of the species biology to enable control over their growth and life cycle and marginal edge factors. Marginal edge factors include an ideal site location within the species geographical parameters, high quality water, an optimal temperature regime, company horizontal/vertical integration. Though a species may not satisfy all selection criteria any deficiency may be "managed around" or compensated by the strengths of the other criteria.

Development is divided into three stages; the pioneering stage, exciting but with a large cash deficit, the entrepreneurial stage varying between financial boom and bust, followed by the agribusiness stage of market advantage and profitability.

11. Do you think these criteria are generally applied?

1. No. Species are selected for a perceived high market price or because someone likes their taste. Growing the wrong species for the wrong reasons in the wrong places.

2. No. Selection is science rather than market driven. The success stories to date have probably been accidental. For example salmon, demand is world wide and the market around 1,000,000 tonnes of farmed salmonids. It stems from peoples' image or perception of the product developed over a century. In Victorian times salmon were seen as the preserve of the landed gentry and as a consequence has that prestige. Contrast that with striped trumpeter. Market research claims the Japanese love the look of this fish with beautiful stripes and it's a lovely sushi fish but its unknown anywhere else in the world outside of Tasmania.

3. No.

4. Yes. Established aquaculture industry species like salmon dictate considerations for new species. For example cod and halibut's environmental reviews were based on those required for salmon production. Salmon is the model for on growing. Marine species have a larval rearing stage. For the hatchery phase sea bass, sea bream or turbot are better models because salmon are easy to grow in fresh water in the larval stages.

5. No. Sometimes new species developers want to grow a species where they live, but the region may not suit the fish. This company started small scale with three Clark swimming pools growing trout, making mistakes, encountering difficulties but learning and finding its niche in the market. It's not a model on how to start a new species.

6. No. Many new species developers are just hobby farmers who don't consider fundamental commercial factors like what market price can be achieved with volume. There must be some benchmarks in lifecycles and production cycles that show up in a desk top review. A level of security is necessary for serious development. A small operation developer is unlikely to do the benchmarks because their financial commitment is limited. They only need to do enough to keep themselves viable. *Even though there is much species development, many of those species are not commercially viable.*

Summary

Selection criteria applied

No (5), Yes (1).

Species selection is often science driven or by a perceived market price, which cannot be sustained as production expands. Many smaller operators begin without conducting a desk top review which will show lifecycle, production and marketing benchmarks. Salmon as a new aquaculture species was well known world wide, contrasting with striped trumpeter which is known only in south eastern Australia. One "no" respondent cautioned against trying to fit a species to its unnatural geographic environment and suggested beginning small scale using a method of trial and error. The result of incorrectly applied selection criteria is growing the wrong species for the wrong reasons in the wrong places. Many success stories were accidental!

Salmon is the master model for the grow out stage of new aquaculture species, but they are easy to grow in fresh water in the larval stages. Marine species are more difficult and have a larval rearing stage. Therefore in the hatchery phase sea bass, sea bream or turbot are better models for marine species.

12. Do you know of potential new species being poorly screened and subsequently developed without proper assessment?

1. Yes. Silver perch, slow growing with a limited market. Consumers prefer ling, orange roughy or trevalla.

Striped trumpeter though not commercialised was poorly chosen. Its selection came from the wrong angle, consumer driven, the fish is beautiful but its suitability for aquaculture not properly investigated. Its not very fecund, has a very small egg size and the lifecycle not properly closed. Limited knowledge of trumpeter's nutrition, herbivorous or carnivorous, are they omnivorous at some stage? After 12 years of research they have an undershot jaw problem and swim bladder problems.

One reason salmon and trout are successful is there are tens of thousands of papers and a couple of hundred years of research into them. Little is known about most of the new species particularly breeding.

Yellowtail kingfish in Spencer Gulf has problems with gill flukes. The Japanese grow them, therefore a big market was perceived. Few yellowtail kingfish are consumed in Australia. Any fish grown here has to compete in the international market. The size of the catfish market in America means the industry doesn't need to export. If the market says produce block white fish, mass market fillets then examine the species for culture to serve that market, that is, grows cheaply, not carnivorous, takes a cheap diet using grain and meal substitutes. If the market says produce tuna, the top end of the market with the highest prices then produce tuna. Each market has different appeal, different opportunities world-wide.

Snapper is known throughout Europe, grown world wide and well understood. Therefore an interesting fish to start with but there is not enough snapper grown to make an assessment. It's grown in the north of Western Australia and up in the warmer temperatures, but it needs trying in the Tamar just to rule it out. It has the market appeal, but not enough is known locally. For aquaculture, sea bass, sea bream are the same family similar to what's being cultured in the Mediterranean.

2. Yes. Striped trumpeter and southern rock lobster. Rock lobster can be enhanced if larvae caught at sea are improved then released. Growth is too slow for intensive culture not generating a quick enough return to justify investment. Striped trumpeter has problems with larval survival and under shot jaw. Striped trumpeter has 3-4 years with Finfish CRC for a major improvement. Striped trumpeter has about 12 years of work with changes in management of the programme and some personnel changes, but larval survival is where it was six years ago. Striped trumpeter is still being investigated because there was not a deliberate approach to its screening. If this work had been done properly 10-20 years ago the industry would have been more strategic about what its trying to develop and striped trumpeter may no longer have been considered.
Striped trumpeter will not be another salmon industry. Tonnage will be limited. Tasmanian salmon farmers would argue that money going to striped trumpeter research might be better spent on amoebic gill disease research.

New species development tends to get caught up with financial time lines, business plans, political timelines which are short term in relation to agricultural development. Terrestrial plant and animal species under culture were developed over thousands of years. There is a danger of thinking 20 or 30 years is a long time. Technologies, genetic and otherwise are now available to assist in domestication. Gains can be seen, understood and managed to obtain improvements over several generations that would have taken hundreds of generations previously.

3. Yes. Silver perch has not been properly evaluated and screened.

Yabbies were poorly investigated and marketing poorly handled. Sixteen dozen small farmers in one State going to a market with a plate of dead fish and saying "who wants to buy these" is poor marketing.

Flounder (in general, not just greenback) will not succeed until the wild fishery is wrecked. Wild caught flounder from New Zealand occasionally floods the market. Aquaculture consistently produces good quality as opposed to the wild fishery that characteristically produces gluts, sometimes with quality, sometimes not. Flounder has potential to be a good fish but not until the wild fishery is wrecked.

In Europe summer flounder has been replaced commercially with the more cost-effective turbot which will go well in Europe. Turbot has bypassed the flounder in the category of smallish flatfish. In the Japanese market product grown here is not known in Japan and therefore has some difficulty in that market, it's an issue of which side up the eye is. Flounder in Australia are left-handed and in Japan right-handed.

Scallops have potential, with a huge amount of demand, but can be impacted substantially by wild fishery.

4. Yes. Greenback flounder *(Rhomboselea tapirina* Günther 1862) in Tasmania is the classic, probably pushed by biologists/aquaculturalists who saw a flatfish species and thought it could be developed based on overseas work. Trial runs indicated a limited market which would not cover production costs. Technically achievable, it is not an economic prospect because no market. A Japanese niche market hasn't materialised. Like cod was, flounder is sitting on the shelf waiting for the market to pull it into production. A similar flatfish considered for development in the UK is lemon sole *(Microstomus kitt).* Only 5,000 tonnes were caught a year, hence market pull from Marks and Spencers and another big wholesaler Bluecrest. Lemon sole looked technically impossible. Larvae were in the plankton for 6-8 months of the year and the growth cycle slow, 3-4 years to get to 500grams-1 kilogram. Re-circulation keeps the temperature at their maximum for growth, 17-18°C which would increase their growth rate, enabling maturity within 22 months. The long larval rearing phase is expensive and even with maximum growth in intensive conditions, the rearing costs would raise the price above market tolerance of about £5/ kilo. Market pull is there but it cannot be technically achieved.

Striped trumpeter lacks market work. Wild caught volumes fulfil the market demand. The advantage of striped trumpeter as a potential species is it grows only in

Australia and New Zealand. Getting people used to striped trumpeter is a marketing problem.

5. Don't know.

6. Yes. Seafood Online's attempt at barramundi cod and coral trout not only hurt the company, but the whole aquaculture industry. Striped trumpeter could have been advanced five or six years ago. There is no reason why it cannot be successfully developed, but its not had the commercial backing it should have. An aquaculture company is investing small sums of money and tying up the intellectual property of the species, therefore the rest of the industry lost interest. A proper process was not followed which retarded striped trumpeter's development. With wide industry support trumpeter could be in trial pens within 3-4 years. The developer must be careful the chosen species is difficult to replicate by low cost producer countries especially China.

Summary

Species poorly screened

Yes (5), Don't know (1).

Striped trumpeter (4), silver perch (2), flounders including greenback (2), yellowtail kingfish (1), snapper (1), barramundi cod (1), coral trout (1).

General problems are the species is not well known, lack of a market, not internationally competitive, life cycle not closed, technology transfer problems, larval rearing and growth rate. Though not commercialised, striped trumpeter is either a failure, a species that should not have been attempted, or one needing another chance because the new product development process was not properly applied. Trumpeter has market appeal but its suitability for aquaculture is not yet properly investigated and has encountered technical problems in larval rearing with undershot jaw and swim bladder.

Silver perch slow growing with a limited market.

Yellowtail king fish lacks a market and snapper though well known and technically achievable is not grown widely enough in Australia to make a proper assessment.

Flounders lack a market because there is still a plentiful wild catch.

Being crustaceans, rock lobster and yabbies fall outside the parameters of this project.

13. Should fish farmers examine the possibilities for new species as ongoing business research, or expand production of already established species?

1. Both. Expand production to build the business to its full potential whilst looking out for other opportunities. There is an over supply of salmon and trout. A diversity of species would help Australian aquaculture ride the supply/demand curve. Polyculture must have production synergies. In Norway saithe *(Pollachius virens* Linneaeus 1758) gather around the sea cages in shoals. It's not another aquaculture species, but a by-product of aquaculture which the Norwegians net and sell.

2. Both. Constantly scan the market environment analysing options for expansion and have a contingency species in the pipeline. A future striped trumpeter farmer needs to be aware of the potential to saturate this market quickly, therefore a diverse product range is needed, but a salmon farmer has a large potential market. Global products are salmonids, prawns, lobsters and oysters. Beyond these, the market tends to be local.

3. Depends on the situation. Salmon has a 40% world wide production surplus, so to consider production expansion of salmon a tidy, unique niche market is needed. Over production was caused by good prices for 2 or 3 years, in particular with Chile and Norway. Last year in Tasmania conditions were bad and fish didn't survive.
This year summer was easier facilitating large inventories in an over supplied market.

4. Depends on the situation. Diversity of species is better than a mono-culture if the company can afford it, though farming alternate species can cause loss of focus. The company has a management structure with experience in certain areas. Developing a new species takes experienced individuals away from the focus of main production.

Commercial companies need a return on their investment, a short-term measure unless it's a big company taking a longer-term view, for example Stolt Sea Farm had a longer-term view to offer the consumer a basket of fish. Stolt started off with salmon, then moved into halibut which didn't go well because they farmed extensively.
Stolt persevered, bought up some of the turbot farms and developed bass and bream in a long new species development phase over 8-10 years during which they lost money. Salmon was profitable which propped up the new species. With salmon marginal world wide turbot returning a profit. Stolt, a big company took the long-term view and now

have their basket of fish to offer the consumer. One species will do well when another doesn't. It's a balance.

5. Depends on the situation. Diversity spreads risk, but if a company sticks to one thing they become very good at it and lower production price. This company grows salmon and trout that are similar in product. Ideally the company would grow 70% salmon, 20% trout and 10% new species.

6. Depends on the development stage the current species is at the market. If under supplied grow and foster, if heading toward maturity look at a new species. The company is a seafood company, therefore will always look at new development of other species concurrently with its existing operation. This and another company were the first in Tasmania to grow both salmon and trout. Husbandry practices differ between species and this applies to salmon and trout. There are few successful trout growers and the ones going well in the market concentrate just on trout. The company's participation in wild fisheries helps leverage aquacultured product into the market.

Summary

Expand existing species or develop new species

Depends on the situation (3), Both (2), Depends on the species development stage in the market (1).

Currently salmon and trout are oversupplied and though salmon still has a large potential polyculture with another species, possibly striped trumpeter or a general diversity of species and product range (3) would help Australian aquaculture ride the supply/demand curve. Australian aquaculture should constantly scan the environment and have at least one contingency species available. A British company developed "a basket of fish" offering with salmon supporting the development of halibut, turbot, bass and bream over an 8-10 year period. After that long development phase turbot became profitable when salmon wasn't, justifying developing the new species.

A species or its derivatives may only have a limited product lifecycle in the market, whether it goes out of fashion or like salmon floods the market. Therefore a *seafood* company will always look at developing another species concurrent with existing operations, especially if the new species has production and marketing synergies. The advantage of staying with one species is continually building a knowledge base and lowering production costs.

14. What attributes should an aquacultured fish have to survive and thrive in the marketplace be it domestic or export?

1. Fresh rather than frozen and accessible to a mass market or to a gourmet niche, high priced market. It must be priced right to sell and get a return. Presentation is important for example catfish are sold as fillets which look acceptable whereas a catfish doesn't. Salmon and trout can be sold as whole fish, because they are attractive and appealing, or in a range of fillet, cutlet or portions or value added forms. The salmon and trout industry value-add about 70% of its production.

2. Quality and convincing consumers that the aquacultured product is as good or better than wild product. Consumers' believe natural is good and unnatural is not good, an issue for intensive aquaculture generally.

3. The credibility of being safe with no disease and minimal, preferably no use of chemicals, antibiotics without dioxins and PCBs present in the flesh. Seafood grown in a safe environment giving people absolute confidence in its origin. There are market specific requirements, a wide variable; soft fish versus firmer textured fish, white fish versus a pink coloured fish. For example consumption of a pink coloured salmon in China was taken up only in the last 4 or 5 years. They prefer a white fish to steam cook. The product should be well packaged and presented and consistently good quality, not necessarily excellent, but consistently good and reliable supplies.

4. Consistency and availability. With Tasmanian salmon the right size for the market every week of the year. Salmon grows fast in Tasmanian conditions. There are gaps in supply and dips in the weight range. The market wants a 4-5 kilo fish and sometimes the offer is only 2-3 kg. A new species has to close that gap. With halibut the developers from the outset tried to phase in small volumes to maintain the correct market size available every week of the year. Aquaculture offers consistent quality as a benefit over fishing, harvesting to order, icing and delivering the fish 5-6 hours later. Aquaculture must be perceived as being clean and green.

5. Sustain a price and if targeting the export market ensure a competing species is not grown cheaply overseas. Salmon grows well for the market, is good eating, looks unique and good, is pink and smokes well. Salmon is a bit special in the world of fish. The meat industries have sheep and beef performing well and smaller niche products like deer and goat that don't perform as well but are still on the market. The same with duck and turkey in relation to chicken on the poultry market. Salmon around the world is a big item fish because it suits aquaculture and it suits the market. A good alternate species might be the duck or turkey of aquaculture with a smaller speciality market.

6. Shortage of supply. Flesh characteristics of the fish dictates the type of market. There will always be a success somewhere. The market just has to be found. For example carp in Australia, a horrible fish yet the British love it. The question is can it be grown for economic value compared to what that market is prepared to pay.

Summary

Surviving and thriving in the market place

Consistent quality (2), sustain a price (2), fresh (1), safe (1), presentation (1), value adding (1), confidence in fish's origin (1), shortage of supply/scarcity (1).

Flesh characteristics dictate the type of market a species serves and a market available for most species. Presentation is important and the appearance of an ugly fish may be disguised by value adding. Salmon enjoys a major success factor of being a beautiful fish that can be sold whole or value added enabling the industry to value add 70% of its production. Other survey data describes striped trumpeter as a beautiful fish. Consumers need convincing the aquacultured product is grown in a safe environment is consistently good quality, not necessarily excellent and as good if not better than wild caught. A species should either serve a mass market like chicken or a niche market served by duck and turkey in the poultry market. A parallel in the meat industry is cattle and deer. Most important is that a species is able to sustain a market price that assists the capacity of farmers to deliver good quality regularly.

New product marketing

15. Where is your market?

1. Australian domestic and 5% niche export market in Asia. To build the export market the company must produce a cost-effective competitive fish. The economies of scale come with increased production. The market is boom and bust with consumers shopping for specials and bargains, which flows through to aquaculture because the (wild fish) distribution network knows only pushing down the supplier price to maximise return. They don't understand what can be achieved with price stability. Price is driven down which if kept up in a competitive environment playing producers off against each other, producers become price takers, the price becomes too low and unsustainable which is a problem for white fish because it's such a competitive market.

2. The company is a co-operative owned by its customers. The market is restricted to five salmon farming companies in Tasmania, Tassal, Nortas, Aquatas, Huon Aquaculture Sevrup which is now part of Petuna. The company sells one-year-old 93 gram smolt for $1.55 each. 25 cents per fish is dedicated to establishment of a new hatchery. Other hatcheries charge $2.10/smolt.

3. Australian domestic and export to Japan (major), the United States and South East Asian markets. Within Australia Sydney represents the majority with about 60%.

4. 80% Australian domestic and 20% exported to Japan. This mix is dictated by market price and production costs. Gill amoeba in summer increases production costs because the fish are pumped once a month into fresh water baths requiring extra staff. Gill amoeba means the company cannot compete on the international market. The fish exported to Japan goes as niche quality into a niche market. Salmon from Tasmania get to Japan quicker than most other international salmon producing countries. In colder climates stocking levels are higher than Tasmania where salmon are farmed at a lower density, driven by higher temperatures and lower oxygen and resulting in full fins on the fish. Therefore they look better quality. The Australian market exists because few people import (because of disease issues) into Australia. The company contract grows for Tassal, Aquatas, Nortas and sells to the bigger fish processors, a salmon smoker in Adelaide and merchants Sydney. The company expects to sell more to the wholesalers and processors rather than contract grow because the margins are small and the market oversupplied with salmon.

5. Australian domestic and a 1% niche export markets. The large markets overseas are being served by more efficient countries than Australia.

6. Australian domestic with growing export market in the USA, Asia and Japan. The company focus is on fine dining, high affluent type areas concentrating on getting the product to the client fresh in mint condition. Tasmanian and Australian producers will never have the economies of scale to compete in a mass world market. In Japan specific market segments can afford to pay the price for the consistency and quality of Tasmanian salmon, but the industry must retain high standards to service this market. A new species need not have global appeal. If it's a very difficult fish to grow and will never be produced in large quantities a big market is not needed. Even with global appeal Australia may not be able to produce enough, only big producing countries like Norway with large water resources can supply a massive market.

Summary

Market location

Growers concentrate on producing a high quality fish for the Australian domestic market which exists because few people import due to disease issues and a 1%-20% niche export markets. A new Australian species need not have global appeal, as Australia will never be able to produce enough of it to satisfy a world market.

Price maintenance is important for the domestic market; especially white fleshed fish and the export market requires fish to be cost effective and competitive. Tasmanian salmon, farmed at higher temperature and lower densities are generally better quality than salmon grown elsewhere and must retain high standards to serve the Japanese market.

16. Did you have to establish a market or was it already established with either wild harvested or other aquacultured species?

1. No, the company has an established sales network. Individuals developed relationships over time with a large trawl fish producer handling and processing 70% of the fish coming through the State. The company jointly marketed wild caught and aquacultured species piggy backing salmon and trout and trawl fish products and vice versa, linking the company to their distribution network.

2. No, it was there from day one.

3. Wild salmon were imported into Australia pre-1986, in small quantities and poor condition and not the consistency and quality of Tasmanian farmed salmon. The efforts to develop the salmon industry in Australia were substantial. Between 1986 and 1989 the first harvest was 60 tonnes and the last harvest (2001/2002) was 1600. It went from a period of short supply priced at $23/kilo in Australia to 1600 tonnes with 16 producers. The market in Australia couldn't absorb it. Early rationalisation and restructure up until 1994 put the industry in a position for survival and profitability delivering a couple of years of positive returns, but the last three or four have been fairly chequered.

4. The market already existed when this company came in because of international production and Tassal was producing in Tasmania. The range of customers has increased.

5. No, in Australia a market had to be established. There was no wild salmon, only smoked salmon.

6. This company developed the ocean trout *(Orncorhynchus mykiss* Walbaum 1792) market in Australia. There was no supply into the market even from overseas. Ocean trout was picked because the company was a new entrant to the whole industry and ocean trout was a niche species that could have a niche in the Japanese market with its subtle variations of flesh quality and presentation. It has taken 8 or 9 years to develop that species which now commands a price similar if not higher than Atlantic salmon in the market. There is some substitution, but trout is a different product from salmon with a market niche. Salmon was developed over time by bigger growers than the company.

Summary

Established market

Australian consumers were familiar with fish called "salmon" either as wild caught salmon, imported pre-1986 or smoked salmon. One company jointly marketed wild caught and aquacultured species, piggy backing salmon and trout on trawl fish products and vice versa, thereby linking the company to their agent's distribution network. The trawl fish may have included Australian salmon *(Arripis trutta* and *Arripis truttaceus),* popular recreational fish, occasionally available in the markets, but usually canned. Neither farmed Atlantic salmon nor farmed ocean trout had a market profile in Australia. Both markets had to be developed. The responses reflected differences in each company's entry to the industry. Of the remaining companies surveyed, one was pivotal in establishing farmed salmon in Tasmania, two others established ocean trout, and one simply picked on the created market.

17. How do consumers' perceive your product?

1. It is well received in the market, is the best advertisement and sells itself on par with the competition. The company promoted the product at Festivale 2002 in Launceston, a public relations, promotional activity.

2. The markets for salmon are varied, wholesale, catering and a basic customer consumer market in a range of forms from whole animal, HOGG to highly processed. products. World wide salmon is a commodity and in Europe is a cheap fish, becoming like chicken with potential for an everyday product. Not in Australia but may become so increasing market volume. The industry is targeting the DINK's (double income no kids) who like to eat and live well.

3. Healthy, safe food because no chemicals or antibiotics are used which the company needs to emphasise. The perception of taste, flavour and texture is good and the fish value for money.

4. The company sells on quality and is probably better able to do that than any other Tasmanian salmon company. The fish are grown on contract, therefore not branded though changed conditions in the industry may force a brand.

5. When the company started selling salmon, European chefs had knowledge of salmon so were happy it was suddenly available here. Consumers probably initially saw our product as a very expensive upmarket fish they would serve on the more expensive end of the menu. Now they see it as more readily available, cheaper with a higher use.

6. It started off poorly probably due to the quality of the stock produced in general, not just this company but State wide. Until consistency is achieved in supplying quality fish, a market niche can be achieved on price substitution. Marketers say (trout) is red fleshed but sell it as salmon because the price can be screwed down as it hasn't got the marketing edge of salmon. That was the substitution effect but now it stands in the market place as a product in its own right.

Summary

Customer perception

Worldwide salmon has become a commodity but not yet in Australia where it's well received in the market. Australians see salmon as a healthy, safe food. The perception of taste, flavour and texture is good and the fish value for money. Trout is a similar fish with a market of its own and both fish sell on quality as either whole fish or value added at least on par with any competition.

18. Where is your competition and can your market grow?

1. The market is growing at 30% pa retail and 10-20% food service end. If the trend continues as in the United States, Europe and the UK then it should continue for 5-6 years before it flattens out. There is still scope, but supply outstrips demand.

2. Independent salmon smolt producers in Tasmania. Even with our shareholder structure not all are solely sourced from the company that currently produces about 60%

of the smolts in Tasmania.10 years ago it was 100%. Some growers source additional product from other suppliers and some are vertically integrated.

3. Australian competition comes from the Tasmanian producers and also in Australia the fish compete with imported New Zealand King salmon which is a different species. There is some imported salmon in the market which will increase probably from Norway. Some smoked salmon comes from Denmark, Norway and Canada. Externally the major player is Norway then Chile, Canada and Scotland and all are able to access markets more swiftly than before. Electronic mail (email) has opened up new channels and opportunities. Over production has caused prices to fall and markets are being saturated for cash flow.

4. In Australia competition comes from other Tasmanian producers and the market is well supplied. It will grow but slowly. Abroad massive competition from Norway, Chile, Scotland, Canada. The company sells on quality, important when competing against salmon from other countries and can provide all sizes each month. Quality is important as neither the company nor the Tasmanian industry can mass produce.

5. Other producers of salmon and trout and probably competition from any other protein source. The market can certainly grow and is growing, but production and market growth must be kept in line, an equation that does not always happen.

6. Atlantic salmon has direct domestic competition and competition internationally from predominantly New Zealand salmon. Chile and Norway are potential competitors but far away, necessitating frozen product that would not get a premium price. New Zealand at this stage is the only competitor which could take market share away. The $AUD has helped, if around 70 cents ($US), the Norwegians would export more salmon to Australia. Nortas and Van Diemen are domestic competitors with trout as are some dabblers with quality problems who get crucified on price. The trout market is now sufficiently mature where a certain grade of quality is expected for the price, if not they discount it quite heavily. Internationally the opportunity is to offer a product to the world which is different. The salmon market is oversupplied. Trout grows in popularity and is achieving a niche in its own right. Its very popular in Europe, more of the plate size freshwater fish than sea grown fish. The market opportunity is good because of its oil content, colour and potential to substitute for tuna. Trout has different characteristics from salmon in flesh, oil content, how the product can be used and presented, attracting different consumers. This trend may have taken some of salmon's market share but has also grown the total market. Consumers eat trout because they want to. Trout isn't seen as a salmon substitute.

Summary

Competition and market growth

In Australia the competition is other Tasmanian salmon and ocean trout companies and imported New Zealand and (to a lesser extent) Norwegian salmon. Externally the competition comes from the major player Norway then Chile, Canada and Scotland. Generally competition comes from any other source of protein which must include. The salmon market is over supplied, but the market for Australian produced salmonids grows steadily and quality vital because the Australian industry cannot mass-produce. New Zealand can supply fresh fish and therefore the only competitor that could take domestic salmon market share. The trout market is sufficiently mature for prices to stabilise and trout has established as a species in its own right. The market opportunity is good because of its oil content, colour and potential to substitute for tuna. Trout has different characteristics from salmon in flesh, oil content, how the product can be used and presented, attracting different consumers. Trout isn't seen as a salmon substitute. This may have taken some of salmon's share but has grown the total market.

19. To what extent does the market drive new aquaculture species development?

1. The market should but it doesn't. The market is not interested in continuity of supply. It's supply and demand and that drives prices too. If a shortage occurred the market wouldn't say grow a certain species. Start at research move forward, somewhere in the middle where the graphs intersect is the grower and where it can be done.

2. It doesn't. Aquaculture is science driven with governments looking for new business ventures to subsidise regional development. The European Union (EU) subsidised regional development in Scotland and the Government subsidised rural development in Norway. The Government and Tasmanian Development Authority played a major role in establishing the salmon industry

3. It doesn't. The market neither knows nor has the capacity to even show interest. Coles and Woolworths above all could be drivers or generators of interest in new species, if they gave a commitment to take new species each week. Currently they access what is available on a daily basis. The consequence is a poor selection, a poor range of quality and poor consistency. The traditional market operators in Melbourne and Sydney won't be involved in driving new species.

4. Greatly. Market demand is the best pull for a new species development. For example Atlantic halibut *(Hippoglossus hippoglossus* Linnaeus 1758) and lemon sole *(Microstomus kitt* Walbaum 1792). Market pull was strong for lemon sole but it didn't look technically feasible. The lemon sole pull kept the halibut development going even though it was taking a long time. (Note: Both Atlantic halibut and lemon sole belong to the same family, *Pleuronectidae,* right eyed flounders). If a product is acceptable to the market, and the market is not pulling, but it's economically feasible a market can be developed. Halibut is a northern European fish is unknown in southern Europe. Halibut is partially known in France and acceptable in the market but needs development by presenting it as a quality fish and growing the market.

5. Greatly, because many buyers could want the same species pushing up the price which encourages discussion about aquaculture. Any fish that sold for $3-$4 kilo would not be considered.

6. Greatly. The availability of wild stocks may also drive it. Aquaculture can fill a gap in wild stock reduction. A lot of aquaculture has come about because although some of the wild stocks have reduced significantly they are well managed. They are maintaining rather than reducing but the popularity of that species might be growing. Because that market may not be sufficiently supplied prices go up. People think they can't afford to buy the fish which is now at a price level where it's warranted to invest in aquaculture. Whereas if an abundance of wild catch, the economics may not be in it.

Summary

Market demand driving new species development

Greatly (3), Doesn't (2), Should but doesn't (1).

Market pull for lemon sole in Great Britain was strong and though it did not look technically feasible the demand effect kept another right eyed flounder, Atlantic halibut going in new species development. But if there is no market pull and a species is feasible, the market can be developed. Availability of wild stock may affect species demand in two ways. First because a decline in wild stock increases demand and second, if a wild fishery is well managed, maintaining rather than reducing, species demand grows necessitating aquaculture even though the wild fishery is not destroyed, but is on the contrary thriving. Those who responded the market doesn't drive new species development observed that aquaculture is science driven by governments looking to subsidise regional development. The market doesn't care about continuity of supply, supermarket chains could drive it but they take what's available on a daily basis. To develop a new species start at the research and market ends and move forwards and backwards respectively. Where the graphs intersect somewhere in the middle is the grower!

20. In new species development, how does the developer balance market demand for size, quality and continuity of supply against the realities of production?

1. The producer must sell what is produced. The company aims for a 3-3.5 kg trout or a 4 kg salmon because the market wants that size for many reasons. The fillet must fit on backing boards of which 100,000 were bulk purchased. It's geared for a particular size that cannot be produced all the time. For example last summer extremely hot conditions south meant the fish had a gill parasite, amoeba, so harvesting started, but the fish were smaller and less red in flesh colour, because they hadn't been feeding.
Producers need fall back positions. If the market expects a gilled and gutted fish, minimum 2-3 kg and the farmer has one 800 g, it won't sell in that market. Something else must be done, perhaps value adding options, kebabs or marinated fish. The producer must get everything he can for every bit of fish produced.

2. This is not restricted to new species. It's the major problem for aquaculture. Less control over the environment means a struggle with that equation and the issues *are magnified with the new species relative to an existing species.* Aquacultured fish have been in culture for less time, less is known about them and aquaculturalists are less able to manage them. Effort is made in salmon smolt production to try and address the difficulties the grower sector has with providing a consistent product.

3. In finfish culture it's a perennial problem when fish are harvested small to maintain cash flow. It's more cost effective and economical to grow the fish larger, but the pressures of cash flow pressure the fish to market at pan size. It's not cost effective to grow barramundi or even trout just to pan size which are almost gone, replaced with large ocean reared fish. People have developed alternate streams of income to overcome this problem of cash flow. Whether developing a new species in parallel with the main species or have another job and grow fish on the side. Aquaculture is a long cycle and cash flow is important.

4. Try and fulfil the market wishes, but sometimes a compromise is necessary. For example halibut is a big flatfish, the market was used to 20 kilo plus fish, so the fish was sold in steaks. To produce a 20 kilo fish under aquaculture conditions takes 7-8 years. To produce a 4-5 kilo fish takes six months larval rearing then three months in the sea. The 4-5 kilo fish produced within a reasonable timeframe started moving into a market used to big steaks. The grower and the market reached a compromise presenting a whole steak, not a half steak, from the smaller fish that sat on the plate well was still acceptable to the consumer and nicknamed "chicken halibut!"

5. Sometimes the market wants a fish at one size but it's much easier (and viable) for the aquaculturalist to provide something else. A market can be stimulated and made change its mind is on price variations. If the market wants a 1/kg fish but a fish can be produced easier at ½ /kg, raise and lower the price of the former and latter respectively, thereby increasing demand for lower weight easy-to-grow fish.

6. Depends on the competition in the market. In the early stages of a new species the market will accept a novel product which can be produced at that stage. The market understands there are stages with corresponding price points when introducing something new. If little competition and the product are in demand, produce as much as possible in the most economic fashion. Under normal conditions the grower should strive to produce what the market demands, if not, a competitor will.

Summary

Production meeting market demand

The basic equation is *the producer must get everything he/she can for each piece of fish produced.* Production issues are magnified with the new species relative to an existing species. Also the early price received for a novel species does not reflect the regular price it will receive. The producer must meet the market and both the market and grower frequently compromise between what the market wants and what's achievable. The grower needs a variety of fall back positions and the ability to deliver flexible responses to changing market conditions. Fish are frequently sold small to maintain cash flow when it is more economical to grow a larger fish.

Lowering the price of a lower weight easy-to-grow fish will influence demand, the lesser price making it more attractive to the market.

21. How should the aquaculture industry innovate?

1. Aquaculture is not a science though most aquaculturalists came from biology backgrounds. It's a business and cost efficiencies must be examined at every stage. Innovation=technology-lowest cost producer world wide in a world competitive market. The species has to fit the environment as the wrong site makes production uneconomical.

2. Two issues. Production innovation=learning more and gaining better control of the species. Then pre consumption innovation beyond HOGG towards value adding which is limited even with existing species and restricted value adding done with the fish when it was a capture fisheries. For example smoked salmon or smoked oysters generally relate to ancient preservation methods designed to enable longer storage. Hence innovation in harmony with trends in food technology and food preparation. Marks and Spencers manufacture pre prepared meals, which *have the potential to generate a lot of value from relatively small quantities of product.*

3. Environmentally friendly packaging because the polystyrene cartons used extensively in the seafood industry will soon be banned which is nothing to do with new species development, but its linked to the development of the product in the marketplace. Improve the public perception of aquaculture. Terrestrial agriculture has gone full cycle and is trying to improve its image. Detractors target all aquaculture and if not addressed the problem will overwhelm the industry faster than it can find solutions.
It's not 'spin doctoring,' the concept is to develop a cohesive voice demonstrating to the public that what aquaculture does has an effect, has an impact, but consider it on balance as a relatively benign way to produce food.' The seafood industry needs a united marketing voice, like for example the old Australian Meat and Livestock Corporation, that concept in the seafood industry. Advertising is seen at the canned salmon level, canned tuna level, but there is little done on a national basis.

4. Industrial and engineering solutions done by individual operators in close contact with the industry for example, the fish race on the farm for bathing fish for amoeba, its unique. There's scope for applied departments in universities to help with innovation and also aquaculture suppliers.

5. Not asked.

6. Be smarter in adding value to existing products and not reducing price to a level of unviability. Just cutting a fish up is not value adding it's value stripping. In mature markets the aquaculture industry must look at how better it sells itself and how it can sustain profitability within the industry. Many consumers won't eat fish because they think it is too hard, too complex to cook. The product must be presentable as possible, for example chicken. Fish needs to be where chicken is, not in price terms but in giving the customer what he/she wants in a changing environment. People don't want a fillet of fish or a whole fish anymore, they want a specific portion where they can just take it home and prepare in the microwave. This varies depending on the customer base; high value hospitality type requirements are different from the average supermarket shopper.

Summary

Innovation in aquaculture

The areas of innovation identified were value adding, improving aquaculture's image, technological solutions and enhanced business expertise.

Technological innovation in production to learn more and gain better control of the fish and pre consumption innovation or value adding in new product development to generate value from relatively small quantities of product in harmony with trends in food technology and food preparation. For example, presenting the product in an attractive usable form, like chicken with ready to use portions and cooking instructions.

The aquaculture industry should be pro active in improving its image which needs lifting. Polystyrene packaging is soon to be banned necessitating a new environmentally friendly packaging regime. A cohesive industry voice to represent aquaculture as an industry and seafood marketing generally is also needed.

New product processes

22. Do you have a formal process for new product development?

1. Not asked.

2. No.

3. Yes.

4. No.

5. Yes, for derivative products, but not very formal.

6. Yes, but fairly unstructured.

Summary

Formal process for new product development

Yes (3), No (2), Not asked (1).

23. How should the developer of new aquaculture products involve future potential customers in NPD?

1. New products in value adding marketing and packaging move the volume of fish. For example Safcol with tuna in a range of new products. The equation is whether a firm does this or sells fish to another firm for the same job. Vertically integrated or not?

2. Involved from an early stage. With an existing product potential wholesalers or retailers of the product should be consulted to assess their capacity or interest in sourcing it from the firm. With more sophisticated products or further up the chain customer's demands and problems need close attention. For example in salmon smolt production a big effort has been made to address the difficulties the grower sector has with providing a consistent product. So the hatchery produces triploids, fish out of season with photo period manipulation enabling increased continuity of supply. 70%-80% of the growout sectors problems are solved at the hatchery sector by responding to customers requests.

3. Start the NPD process at the marketing end and involve consumers' in the early stages of the decision-making process.

4. Extensively consult the consumer in the market and objectively review.

5. The product may already be available in a wild form, tested in the market with a market price. If not ensure there is sufficient demand, particularly if the Australian market is unfamiliar with it. Start from both ends of the chain, scientific and marketing.

6. Consult them to establish needs, wants and potential satisfaction. Show an example if possible and request feedback on pitfalls and price sensitivity. If they are chain players in wholesale and retail the feedback benefit is mutual. Overall dialogue is needed but their involvement in the entire process may or may not be necessary.

Summary

Customer involvement in the new product development process

Potential customers should be involved from the earliest stage in the new product development process. The process should start at the market and work backwards and at the same time start at production and work forwards to meet at a balance where customer's demands can be satisfied. Having developed a new species (and consulted future customers) the producer must decide whether the firm participates in the value chain after farm gate or sells its fish to a processor to develop as a new product. This effectively divides the process into two stages of *new species development* with customer consultation and a separate process of *new product development* with customer consultation. The product may also be available in wild form and well known so separating new species and new product development may be ideal, as further down the chain customer's needs are more sophisticated.

24. When should representatives from all company functions (research and development, production and marketing) become involved in the NPD process?

1. From the outset. All players should know the stages of development the product is in. This company works with the food technology division of the Maritime College on new products, taking the ideas from research to product development stage, then commercialisation stage and marketing. Because the production crew is growing for that market, they're integrally involved to produce a fish at a certain colour, size and standard.

2. Right at the start and in harmony to prevent individuals going off on a tangent. Marketing people must know what can be done in farming. A weakness in the salmon industry is marketers don't know difficulties faced by counterparts on the farm.

3. From the beginning.

4. Everyone should get together right at the start, discuss the concept, then individuals break off, conduct their research, come back together, review and keep on with this cross functional method during the NPD process.

5. Any new product would ideally be grown within an existing aquaculture operation even if it were funded externally. If within the overheads of the company, the new product should be trialled at very low cost. The theoretical path of developing a new species is different from the practical way where the developer sources a new variety of fish and grows them beside the existing species under culture. Economically this is the best method, juxtaposing the new fish in culture, then "piggy backing" them into the market with existing species at very low cost. Market penetration generates product knowledge and market feedback indicates acceptability. This process may not work because either the theoretical models are too expensive or the practical approach has insufficient scientific backing. Growing a species alongside an existing fin fish operation allows incremental increases of knowledge in production and marketing in the second species, possibly transferring knowledge from one species to the other.

6. Assemble all the new product development players and conduct a desk top review, ensuring an initial contribution by everyone and *a re focus of people at certain times during the growth of it.* For example if a product has a limited growth cycle marketers need asking is this what they want, because their responses will dictate how the product is managed forwards and relate it to production. The development team builds market expectations research and production experiments over the development cycle which may be years. The product at market entry should at least be partially acceptable with 8 ticks out of 10, or six ticks out of 10, but not 1 tick out of 10.

Summary

Cross-functional representation in the NPD process

All new product development players should assemble and conduct a desk top review, before starting, thus ensuring an initial contribution by everyone. Should the new product process begin, all players must refocus at stage gates during the project.
The product at market entry must be at least partially acceptable with 8 ticks out of 10, or six ticks out of 10, but not 1 tick out of 10. A new species could be grown alongside an existing species at low cost and eased onto the market also at low cost. This simpler process eliminates much of the risk of something more formal and allows for low key transfer of production and marketing knowledge from one species to another.

25. How important is the new aquaculture product launch into the marketplace?

1. Very important. The company can push product onto the market, but it needs customer pull. Product marketing and product launch are linked to create awareness of the product and create the customer pull. In the formative years the salmon marketing effort was excellent.

2. Very important, if the product is new and the market doesn't know about it, but if augmenting or piggy backing on an existing capture product, less important.

3. Important, to have an appropriate marketing campaign but it depends on the kind of market and the customer. The launch should be linked with details of the product's major benefits, attributes and availability. When Safcol in Tasmania launched Southern

Ocean Trout at Chateau Reynella in Adelaide, prominent people like Michael Angelakis, Peter Doyle and Jill and George Mure were invited. The function had guest speakers and went very well. The company spent little money, but it extended the product via the journalists and their subsequent write-ups.

4. Timing, content and product is crucial. To launch a new product and get the necessary PR is very easy. The press loves anything new so there is a ready publicity machine. Launch timing is crucial. You've got to get it right. The halibut launch was premature, a big fanfare then nothing happened. People kept asking for product yet not enough was available which turned them off.

5. Very important, because the launch creates a perception of that fish. This company formally launched ocean trout even though the volumes were small. Then under supply the market, to create a demand for the product. Sell into the restaurant trade starting with the very best restaurants as they can make more of a name out of it. Product awareness filters down as more is grown. A launch is a very formal process and the alternative is to dribble small quantities out, gradually finding people who want your product and find the price acceptable and progressively expand the market.

6. Very important because a concept or meaning is sold on quality or novelty. Communicate that to the market explaining why the product is better than the competition. If no one else is in the market explain why customers should buy the product at all and what uses can be made of it. They don't care if it costs $10 kilo to produce the fish and they can only afford to pay $6 for it. Maximise value by selling it to the market in the best and most professional manner. How it's sold to the market it has the ability to increase or decrease the value of your product. For example salmon was seen as a quality fish grown in an environment where the fish is very robust, clean and strong so the market paid $20 per kilo. It had nothing to do whether that fish was worth $20/kilo, but it was marketed so well it was worth $20/kilo.

Summary

Product launch

Very important (4), Crucial (1), Important (1),

A launch creates an awareness and perception of the product and is very important because it sells a concept or meaning and "extends" the product. The launch must communicate why the product is better than the competition's product.

The launch is part of the marketing function and how a fish is sold to the market either increases or decreases its value. Timing and content is crucial as there is always good media support available but the fanfare must be backed by product availability which should initially under supply the market to create a demand. Whatever the technique sufficient product must be available to back up the launch.

26. How does new species development feature in the future of aquaculture?

1. Imperative. Have10 species under investigation and hope one succeeds.

2. Important, if aquaculture is to spread to different regions, therefore new species in appropriate environmental conditions. Consider the equation of existing species produced in larger tonnages or new species produced in smaller tonnages. Irrespective of species, feed issues may limit development. Relative to volume and compared with other industries (fertiliser, poultry and pigs) finfish aquaculture consumes a large proportion of fish oil and fish meal production. Questions of pressure on capture fisheries for carnivorous species feed supply could be a critical decision point on whether or not to develop new species.

3. In the medium term and in strategic planning new species development gives depth to the aquaculture industry. The salmon industry in Tasmania would be comfortable if it had developed striped trumpeter, flounder or another alternate species. A weakness in Tasmania is finfish aquaculture is dependent on two similar species. The question with striped trumpeter is one of economical production. The synergies of striped trumpeter and salmon generate economies of scale relating to current infrastructure, processing, packaging material and transport delivering a pink and white product, both with firm flesh. People in this company are about the last supporting striped trumpeter in the Australian aquaculture industry. Unfortunately the work done during the first seven or eight years of work at Taroona must be discounted because it was mishandled, partly because of the management at the time, and partly because insufficient resources were directed towards it. The Tasmanian Government was close to agreement with IFREMER, which had the expertise. IFREMER wanted $100,000 at the time to develop striped trumpeter. The view was too much money and the French will take away some technology. This arrangement would have been cheap at twice the price and the industry far ahead now. Striped trumpeter as a potential species has fallen into a trough created by the new government thinking. New species development was a province of the developmental arm of State Government. State Governments had a regulatory arm and a developmental arm. The money, effort and resources that went into oyster culture, scallop rearing and flounder were the province of State Governments. The amount of resources that goes into regulatory affairs now far exceeds resources that go into development. The regulatory arm of government has grown proportionately bigger which sets up it's own cycle. Striped trumpeter has come at a wrong time in this context and appears to be one of the most difficult species because of a bottleneck in larval rearing. Striped trumpeter is defended on the basis of, if it can be cracked here, it is a species Australia can do better than others in Tasmania, parts of Victoria and perhaps in parts of New Zealand. It cannot be done cheaply in Thailand, Singapore or China quite so easily because Australia has the basic requirement of cold water, apart from all the synergies.

4. It is a major part of the future. New species, especially new marine species will spin off from operators in established industries like salmon, bass, bream and turbot. Once one marine species is cracked and cultured, within reason, others can be cultured because they have similar larval development cycles. That established, developers will look to diversify and grow, therefore more and more species grown around the world. The problem with established species is feed source and availability. It's mainly fishmeal, but many alternatives like vegetable sources are under investigation, so with the next generation of new species the availability of fishmeal *per se* will not be an issue. Unfortunately herbivores are not a very good eating fish. The carnivores are better.

5. Important. There is a good potential for a white fleshed, herbivorous fish that preferably does not like water too warm

6. Very important, because the world's stocks of fish are reducing and the population is increasing. It's very important that aquaculture picks up the slack.
Fish is perceived as a clean, green and healthy. In 20 years time aquaculture species will be a normal thing at the supermarket and wild fish will fetch a premium over aquaculture.

Summary

New species development and the future of aquaculture

New species is very important in the future of aquaculture because it adds depth to the industry and enables a regional spread. Three respondents identified feed issues for carnivorous species as a limiting development factor because of high use of fish meal and

fish oil. Diet research is expected to deliver new generation feeds lower in fish products for new generation species. The salmon industry in Tasmania would now be in a better position had it developed a new or alternate species. New marine species will spin off from established industries world wide because they have similar larval cycles.
In 20 years aquacultured species will be normal with wild caught species fetching a premium. Have 10 species under investigation and hope one succeeds.

New product development agribusiness value chain

27. Why is Atlantic salmon successful worldwide and in Tasmania?

1. Salmon's reputation as the king of fish. Its appearance, diversity of carcass uses and value adding potential. For example hot smoked, cold smoked, dried, raw (sashimi) and cooked in every way giving it market versatility.

2. Perception. Salmon's image was lifted from a cheap and plentiful fish to a prestige fish with royal patronage when Queen Victoria established Balmoral highlighting country estates around the UK and salmon angling. Salmonids were transplanted to new British colonies. In aquaculture salmon is robust has a market and efficiencies that enable massive production and profit. Time frame to grow out means an ROI in two to three years. Atlantic salmon are not the easiest salmonid, but easier than many marine species in limited culture. Atlantics produce a large egg, which produces large larvae. Both are easy to manage. The fry can immediately start eating artificial diet.

3. In Tasmania there are some excellent growing conditions which are optimum, but take out the last two years of warm summer temperatures. Prior to that the good growing period was 1994-1995. The FCRs and cost of production were good producing a safe food item. To the Japanese Tasmanian salmon are firm textured, good eating quality for which they pay the highest price in the world for farmed salmon. With Atlantic salmon there was an element of serendipity. Before Atlantic salmon aquaculture took off in the early 70s, the fish was known and esteemed in fish circles. There was an existing salmon fishery out of the North Atlantic and similarly off the west coasts of the United States and Canada, though for a different salmon species. Therefore some background knowledge and because the fishery was an important a lot of industrial and government infrastructure, like the laboratories and fisheries scientists. Against this backdrop some forward thinking. Norwegian fishermen fenced off huge fjords and started salmon there.

The government realised because the fisheries were already in decline, not just salmon, but cod as well there was value in decentralising. Therefore the whole industry was set up taking advantage of existing infrastructure and desire to decentralise industries and give alternate employment to the fishermen. The classic set up was small circular cages, 2-3 cages per farmer with a visiting harvester. The government put in money and leadership=serendipity. The critical mass just grew and grew and that is where the thundering engine of Atlantic salmon farming came from. Why is it successful? That is one reason. Another major factor is that it's a well known, accepted fish, a user-friendly fish, with good recovery. Cooks can do exiting things with it. It looks good, big muscles and few bones, is relatively easy to grow and much is known about the biology.

4. A luxury image to begin with, which kept the price high, ensuring good returns during the development phase. Now out of the development phase and in full production, salmon is acceptable world wide. Multiple uses for the carcass generate a variety of different products split into many different markets. It can immediately be split into fresh product, steak, fillets then you've got the whole smoked product range with hot and cold smoked. The secret behind salmon's success is its versatility.

Atlantic salmon works in Tasmania because geographically it's at the high end of the acceptable temperature regime. The temperature is favourable to fast growth, but too high in some summers. The aquaculture of any species must be where the temperature regime is optimal for growth. For example halibut is a northern temperate species and Scotland is the very southern end of its range, so it grows well there. Likewise with turbot, the UK is the northern end of its range and the industry has developed in Spain at the very southern end of its range. That's the biological reason for striped trumpeter, Tasmania is in the northern end of its range. Whereas with yellowtail kingfish, Tasmania is the southern end of its range hence low temperatures-slow growth.

5. Stages of development and diseases are understood and many trained staff around who know how to grow Atlantic salmon. It's good fish to grow and eat. It looks unique and it smokes well and has high levels of Omega-3 oil. Not all fish has that.
Gut loss is not that great, some fish have large gut loss. Salmon's cycle time is too long, ideally it would be shorter. A white fish with a shorter cycle time is a desirable new species. Salmon in the early years was not marketed well, but it's a desirable fish. Consumers want it because they know its good. Other species may need more marketing

because they lack initial attraction. Orange roughy though not an aquaculture species was marketed into being an acceptable fish. Salmon was caught wild for many years, but in short supply and only for the wealthy sporting people in Europe who would eat it.

6. Original image and developed marketing image of salmon. Readily available in any country at any time of the year and 9 out of 10 the quality is good. The industry is successful in Tasmania because well based technology from overseas was planted into a new market segment, hard to service from other countries and not warranted being serviced because of the small population base, hence a captive market. Government involvement through Saltas regulated industry growth to a realistic pace, didn't allow entrepreneurs to come in, over capitalise and speculate ensuring industry development in a systematic, managed manner.

Summary

Salmon's success

Salmon has an historical reputation as the king of fish. Queen Victoria's Royal Patronage probably established salmon's image as a superb angling fish and British colonial influence transplanted the species to many British dominions and colonies world wide. Salmon is successful because:

1. Image salmon is perceived as an outstanding fish with Royal status. (6).
2. Available technology from Europe where it is well supported by government. (5).
3. Versatile in the market, diversity of carcass uses in value adding. (4).
4. Fast growing, adaptable to aquaculture and Tasmanian conditions. (2).
5. Well marketed. (2).
6. Salmon technology is well understood and people available who know it. (2).
7. Easy to produce juveniles.
8. Well liked by the Japanese and serving a niche export market in Japan.
9. Tasmanian Government involvement through Saltas.
10. Captive Australian market far away from other sources of farmed salmon.

28. Was a new product development process applied to salmon?

1. No. It started with freshwater trout farmers in Tasmania which established some of the technology. Salmon is different, much trickier at the hatchery level. Hatcheries were established to produce fingerlings at Saltas at Wayatinah and the expertise imported. All the research and engineering was understood. Salmon had never been available in Australia so in the Australian market fresh Atlantic salmon was a new product. The distributors supported the producers who delivered continuity of supply, 52 weeks a year, previously unknown. Chefs offered it on the menu for the first time and could leave it there without the hit and miss of wild fish supply.

2. Probably, but extensive culture of salmon is old. Modern aquaculture has closed the lifecycle and augments feeding the fry giving them better start. The activities in Scotland and Norway indicate a product development process.

3. No. It just grew.

4. Yes.

5. No. It just grew

6. Don't know.

Summary

New product development applied to salmon

No (2), Yes (2), Probably (1), Don't know (1).

Fresh water trout farming in Tasmania established some of the technology and the salmon expertise was imported. Salmon had never been available in Australia so in the Australian market fresh Atlantic salmon was a new product. A new product development process was probably applied in Scotland and Norway.

29. The value chain is a series of stages or events from selecting a species for culture, to marketing that species: What are the critical components of the salmon value chain and how are these linked?

1. Produce the fish with the right; size, time frame, attributes, characteristics, colour, external appearance, flesh colour, oil content. The distribution network and processing is vital for quality control and cold chain management.

2. Product perception and knowledge of an ongoing demand. Existing propagation technology enabling focus on grow-out technology which needed development.

Production chain players tend to see each step below them as the cause of all their problems and the step above them as unreasonable and unhelpful. For example hatcheries or feed suppliers are blamed for problems on marine farms. If marketers have difficulty sourcing product, the marine farm is blamed; not the right size or fish haven't been grown properly for the factory. If the factory is not supplying the correct customer requirements to the marketer, something is wrong with the factory. A massive effort has been made in salmon smolt production to try and address the difficulties the grower sector has with providing a consistent product. The hatchery also produces triploids and fish out of season with photo period manipulation so fingerlings go out with increased continuity of supply. In salmon culture probably 70%-80% of grower problems are solved at hatchery.

3. Stocking density in the pens, the physiological features of the fish and their fitness and harvesting at correct pH then reducing the fish to 0°C. At zero degrees the fish starts well in the cold chain.

The company has sophisticated packaging for salmon, a polystyrene insulated box in which goes four kilograms of ice in a bridge. Underneath is a pad to absorb melted ice that so the fish are not sitting in water.

Two three and four-degree insulated vehicles deliver to the airport in a swift efficient transport system. A *vital* link is ensuring the customer has the infrastructure in place to ensure the integrity of the product. For example in the Footscray (Melbourne) fish market, after all the cold chain work done by the company to that stage people have been observed with dirty smoky fingers handling salmon, wiping blood all over them risking contamination of the fish. The company built its capacity to achieve a premium that at every stage of the value chain it did that little bit more and that little bit better which in an holistic sense meant more than company competitors were doing. The company has got both kosher and halāl certification. In Japan the carton is a silver "Ginbako."

4. In production the critical components are maximising survival, maximising growth, optimising the food conversion rate (FCR) and optimising quality. Then optimising the harvest so it's low stress to avoid quality issues at harvest, chilling it down quickly, so it doesn't warm up or affect the quality there and processing the fish when not in rigour. Salmon are reasonably hardy, but because Tasmania is just at the higher end of salmon's temperature range they become more susceptible to disease.

Overseas cod had production issues. The larvae are cannibalistic and eat each other. This is lessened by careful tank design to stop larval encounter rates, careful grading and extra food. Also males mature early at a small size. This is overcome with all female production or the use of lights to move the maturation window one way or the other. The market stopped development of cod. Although cod was scarce, wild catch volumes and price would go up and down. Aquaculture production cost was about market price so no profit margin. A few research institutions produced larval cod and in the process discovered production issues, then entrepreneurs invested getting cod to market but found out they couldn't make money. Over fishing and therefore scarcity has started pushing the price of cod up above the production thresh holds giving aquaculture an economic chance hence the recent upsurge. Cod's production problems can be solved with extra resources.

Halibut was a long development phase of 10-15 years and is still a new species, not profitable but the first operators are about to make money. Halibut is a cold water species and has a long five-month larval development from egg to weaned juvenile in cold water so much can and did go wrong. Grow out phase is three years. In the larval development phase much was made of the complexities of fatty acid ratios in the diet by the academic institutions. Industry entrepreneurs arrived and used standard off the shelf diets and got results. The problem was rearing conditions given to fish rather than diet. The main hatchery is in Fiske in Iceland and Otter Ferry in UK, Alistair Barge. There are operations in Canada with links to Fiske in Iceland. A hatchery in Norway keeps having problems trying to grow halibut extensively on copepods, which doesn't facilitate sufficient control. The copepod population would crash and poor hygiene caused viral diseases. With the intensive systems used in Iceland and Scotland everything can be disinfected. They use artemia which can be disinfected and enriched giving more control over the system. Norway produced a lot of halibut with the extensive system very quickly. The crashed basically they got a *nodavirus* in the copepods which infected the larvae. The intensive system was slow at first but now has reasonably predicable larval survivals. Sometimes it crashes and other time comes through with high survivals. It's all about attention to rearing detail.

Turbot was exactly the same. It's all about larval rearing. Stolt Seafarm are now the major producers, about 70% of the turbot. Turbot was a luxury fish, niche market, well known in Europe so a good market price. There are a few luxury niche fish like turbot, halibut, sea bass competing for the same dish in the restaurant. Turbot struggled with the larval rearing similar to halibut, is now intensive and overcoming problems with attention to detail, hygiene in the hatchery stage. Turbot couldn't be grown in cages, they sit on the bottom, so tanks were deployed, an expensive way of growing fish because of construction costs and water pumping. Production increased slowly, the market absorbed supply whilst the price kept high. The market grew on a continuous growth curve without being flooded. Turbot takes only 4-5 years after hatchery construction to have predicable volumes of fish coming on to market, so any new product coming along can be seen. Stolt produce 70% of the turbot and control the market and dictate what goes out where and when and now the turbot is increase to the point where they produce about 3,000 tonne per year. The wild catch is about 9,000 tonne a year. They encountered a few larval rearing problems and problems in grow out, but overcame them.

Cod are still fine tuning larval survival. Turbot's hardier than halibut hence easier. Cannibalism is an issue and manageable with increased food supply. There's a maturation problem in the sea, but lights and possibly all female stock may overcome this. Cod isn't a luxury fish like bass, turbot or halibut so it has the potential to have a wider market. Bass, turbot and halibut are restricted to a luxury niche market in a restaurant. Turbot probably wouldn't produce more than 10,000 tonne, with the wild catch that would put you up 15-20,000 tonne, halibut probably no more that 10,000, sea bass 20-30,000.

5. Cost of production, the risk of production and geographical location.
Owning a hatchery gives the company a big competitive advantage.

6. Reducing costs through the value chain now being replaced by additional costs of quality and changing social obligations for example environmental monitoring and the impact of wild stocks the like jellyfish and seals in southern Tasmania. Striving for excellence in the hatcheries with harder grading and fish going to sea performing better than before. Fish rearing in the sea, feed practices and technology. More science needed on nutrition and stocking densities. In the distribution and marketing chains cost of production may well be as low as 40%-50% of the value to a wholesaler or person on the street. It can be as low as 33% of the cost, but what they are paying for is the cost of rearing that fish. The distribution and marketing chain are significant imposts depending on how integrated the company is or how efficient that chain. The operation of the chain can make or break the profitability in a species. Developers must be realistic about developing a new species or being a new entrant into the market. People in the value chain will take a part of the producer's profit because the product goes through 2-3 sets of hands hence a high price is not necessarily an indictor of a profitable species.

Summary

Critical components and linkages in the agribusiness value chain

The value chain is initiated by idea generation, but as salmon was already established, the technology imported, a government hatchery established and a profitable market known to exist, respondents began chain analysis several stages along it by noting the effort and success in improving smolt production to assist growers in providing a consistent product. In addition the hatchery produces triploids and fish out of season with photo period manipulation, increasing continuity of supply. In salmon culture probably 70%-80% of grower problems are solved at hatchery and owning a hatchery gives a company a competitive advantage. This important work gives enables a focus on grow out technology and stocking densities to enhance the fish's physiological attributes of size, frame, appearance, colour, flesh colour and oil content. In production the critical links are maximising survival, growth, optimising FCR and quality, these in turn link to cost of production, risk of production and geographic location. More scientific work is needed on nutrition and stocking densities.

Salmon in Tasmania become more susceptible to disease because the State is in the higher end of salmon's temperature range. Production chain players tend to see each step below them as the cause of all their problems and the step above them as unreasonable and unhelpful.

Cold chain management starting with harvesting at the correct pH then carcass reduction to 0°C enables the fish if whole, to enter the cold chain distribution network in good order. Correct packaging is important. A vital link in the cold chain is ensuring the first "customer," the fishmonger has the infrastructure to ensure the integrity of the product.

In the market product perception, knowledge of an ongoing demand and observance of religious standards for food preparation like halāl and kosher assists the product's appeal. Even if fully vertically integrated product passes through several "sets of hands" in value chain each taking a percentage of the producer's profit therefore a high price is not necessarily an indicator of a profitable species. The distribution and marketing chain are significant costs and reducing costs through the value chain now being replaced by additional costs of quality and changing social obligations. For example environmental monitoring and the impact of wild stocks like jellyfish and seals in southern Tasmania. Overall value chain operation can make or break species profitability.

30. Could another species achieve salmon's success?

1. Yes, but hard to find a fish with the world wide ubiquitous appeal of salmon. Many species are under development; rock lobster, abalone, tuna, crabs.
Silver perch, jade perch and Murray cod will never have salmon and trout's world wide appeal. Barramundi could become a standard fish and chip species, perhaps snapper.

2. Yes, prawns, oysters, lobsters but not another marine fin fish because nothing has that global recognition from which demand springs. For example striped trumpeter, taking it to New York is like bringing striped bass to Australia.

3. Yes, striped trumpeter could if its life cycle is successfully closed. Not enough is known about the technicalities of getting it to a commercially saleable size, but there is interest in the marketplace. There is a huge demand for white, firm oily fleshed fish.
It also contains huge amounts of Omega-3 polyunsaturated fat, more significant or substantial than salmon. It has many benefits, one being the regional nature of its occurrence in the Southern Hemisphere. It is virtually unique to south eastern Australia. In the Japanese market, the DHA's, EPA's, Omega-3's are important elements of the marketing focus. Much of this is unknown in Australia but gaining recognition.

An expensive fish which may be a possibility is the Japanese puffer fish, the fugu.

A species can be successful in limited markets for example catfish in the United States has good customer attributes, a brilliant white fleshed fish for American tastes.

Cod *(Gadus mohua)* has been recently decimated and possesses good attributes; fast growing, not as demanding as salmon and is well known. The same people who developed salmon farming have taken on the aquaculture of cod. Cod will be one of the big new species. It may eventually rival salmon in production.

4. Probably not. Tuna may. The fish must be acceptable right around the world and tuna is known in all countries.

Cod could have a mass market but not wide spread as salmon because salmon had that luxury cache and could be split into the different products. Cod is known in the northern European countries where it's eaten and was exported in the old days to southern European countries like Spain where its not caught, but known. Its market is limited because it's just another white fish.

A new species need not be global but it must be profitable. Halibut is a quality niche species, its industry small and profitable. The obvious candidate in Australia would be tuna because it's acceptable world wide with a massive and profitable market.

5. Yes. Possibly yellowtail king fish. But its not a herbivore and likes the warmer water so unsuitable for Tasmania. Some of the species cultured in the Mediterranean might be interesting for Australia.

There is reason to believe that a good white fish which is herbivorous and low cost to produce could become the chicken and salmon might end up being the turkey because it's more expensive to grow. The price of salmon cannot go below a certain level because salmon eat expensive fishmeal and fish oil.

6. Yes. For example tilapia is grown in large quantities in Asia, but may not get world wide acceptance. It will be successful for quite a large segment. Salmon is not successful right across the world either, because people can't afford it. There are species just as successful. Overseas companies are still growing salmon but diversifying into other species, because they can see maturity in the salmon market.

Summary

Another species achieving salmon's success

Yes (5), Probably not (1).

Respondents though positive, saw salmon's success as difficult to replicate. Salmon is now selling into a mature market. Two markets were generally delineated, mainstream like salmon and limited like catfish in the United States. Barramundi, snapper, striped trumpeter and yellowtail kingfish may be successful but with limited potential in Australia.

There is demand for another white fleshed global species and respondents saw cod and tuna as likely contenders with cod a possible global rival for salmon. Striped trumpeter could be as successful in Australia as salmon. The market is interested but the life cycle not successfully closed, nor is enough is known about the technicalities of getting it to a commercially saleable size. There is demand is for white, firm oily fleshed fish. Trumpeter contains larger amounts of Omega-3 polyunsaturated fat than salmon. Trumpeter is virtually unique to Tasmania, a significant comparative advantage.

Trumpeter has production limitations and is unknown internationally.

There is reason to believe that a good white fish which is herbivorous and low cost to produce could become the chicken and salmon might end up being the turkey because it's more expensive to grow. The price of salmon cannot go below a certain level because salmon eat expensive fishmeal and fish oil.

31. How important are strategic alliances in new product development?

1. Crucial. The company forms strategic alliance with research institutions for building engineering models, developing products with food technologists, hatchery and new species development. The firm needs these alliances. Production, processing and value adding is fundamental to a vertically integrated company. A decision point is does the fish farming company become involved in the value added chain or just sell the fish to specialist product developers. Aquaculture is short of entrepreneurs to drive the industry forward. Entrepreneurs have business expertise but don't understand aquaculture. The industry needs businessmen who understand aquaculture.

2. Very important. Salmon started with strategic alliances between research institutions, feed mills and industry. Saltas was set up as a co-op where potential on growers of product and the government came together to foster the development of fingerling production. The synergies from those alliances contribute to the success or otherwise of the venture with very strong feed back mechanisms and recognition of interdependency. In Britain a large company with strong R&D and a stock feed capability didn't need the tertiary sector in development because its R&D arm is so large.

3. Important. There must be liaison between talented producers and talented marketers, different skills but both are essential. Strategic alliances come within and between organisations.

4. Very important because it depends who is developing the new species. For a big company with established distribution chains it would be easy to put a new product into an existing chain. An entrepreneur or an individual company without distribution channels must develop an alliance with a marketer, a bigger company, or existing processors. For this company a strategic alliance with a smokehouse is pivotal.

5. Important. Strategic alliances keep new species development costs down. A new species plan needs a phase of 3-5 years between where it's an idea and when it's commercially viable.

6. Very important. That underpins the success of it because you've got to have commitment from people to sew onto the process. Whether that's from a wholesaler to commit to taking a certain volume, whether he's making $1/kilo one day and 30 cents the next day because your fish is not up to scratch. The ability of a new entrant to compete in a semi-mature or evolving market is important requiring marketing strategic alliances. This company grows smaller tonnages than its competitors in Tasmania but competes because of good strategic alliances which assist when the market is hard, the prices the company tries to command are tough or there is an over supply. An alliance is needed whether with a wholesaler, retailer or a marketing company to give the supplier an edge to compete. Not always the best product in the market sells the most.

Summary

Importance of strategic alliances

Very important (3), Important (2), Crucial (1).

Salmon in Tasmania started with strategic alliances between research institutions, feed mills, industry and a co-operative hatchery, Saltas. The synergies from those alliances contributed to the success or otherwise of the venture with feed back mechanisms and recognition of interdependency. Additional strategic alliances should be with engineering research institutions to provide engineering solutions, food technologists to develop new products, distribution chains and marketers.

32. How big are the issues of site availability, water value and use for new species development?

1. There are always contentious issues when any erstwhile public areas have been allocated to private interests. The role of governments is to facilitate sites, but many conflicting interests exist for those resources. The Furneaux (Flinders Island) Group assessment, Marine Farm Development Plan allocated 760-770 hectares of water for aquaculture. The economics and logistics of getting feed in fish out and fish processed is difficult and must have a multi millions dollar development to work, similar to the Bathurst Island development in the Northern Territory. About seven marine farm development plans in Tasmania were done. The Government thought the Tamar estuary was unsuitable for the survey and needed convincing, eventually doing it last. The Furneaux business enterprise group's consultants said scallops, mussels, oysters, yellowtail kingfish are possible species.

The Tamar River is an estuary not a river. The tide flows up beyond Launceston. The company has adopted the Norwegian fish farm site model with a gangway going straight out from the shore, thereby eliminating the need for many boats as some other company's have to rely on.

Requirements for and properties of aquaculture sites, including the geographical location and environment for a species do not always fit a pre-determined model. For example, snapper up to 15 kilos occur in the Tamar between Beauty Point and around four kilometres upstream from the site which neither fits the parameters for the exotic salmon currently under cultivation or native snapper.

The literature says snapper won't grow below 14°C and require 14-27° C, plus lower salinity conditions, but are not particularly successful within their ideal areas in North West Australia and Port Stephens. In aquaculture the species wild environment does not have to be specifically replicated in culture. For example in a saltwater aquarium, most saltwater species survive and thrive at 28 ppt, but at full salt 35 ppt the species will struggle to stay alive in an aquarium situation. Winters on the Tamar are cool for snapper meaning slow or no growth and reduced feed consumption, but snapper in the Tamar may avoid disease problems and grow spectacularly outside winter. The Tamar does not have a seal problem or a net fouling problem and frequent net changing requirement and is without amoebic gill disease. The Tamar had been overlooked, deemed to be inappropriate, too warm for salmon and trout. Data loggers revealed it was no warmer than anywhere else in the State but when warmer was at peak temperatures for a sustained period. The south of Tasmania could have ten days around the 20-degree mark down the south end of the State where this site may have six or seven weeks. Dissolved oxygen is the problem with high temperatures. In the south of the State, it may spike on high temperatures briefly but during that time the oxygen levels are at a minimum around 2-5ppm. Oxygen levels in this *high-energy* current environment with a fast flowing current are at 95%- 98% saturation, running at 20°C with 7.7 ppm (high) dissolved oxygen. That assists the fish through periods of high temperatures. Trout were always going to struggle in those higher temperatures, which also correspond to higher salinities salmon don't, and are thriving. The characteristics which make the Tamar Estuary a high energy environment are semi diurnal tides with a rise and fall of 2.5 to 3.5 metres and a current flow of 1.5 to 3.0 knots, up to 150 cm per second at the site. Other parts of the estuary experience significantly higher flow-rates. The fast flowing waters run across a deep and rugged terrain and in places large volumes have to escape through narrow openings for example, Whirlpool Reach creating much turbulence and resulting in high oxygenation. The current flow has the benefits of robust, vigorous growth and environmental sustainability. The site is swept clean with no build up of residues. The best flow in the south would be 8-10 cm per second. There is no need to fallow cage areas on the site and move cages around and bridge access to shore means no boats, therefore efficiencies in production.

2. Very important, because of competition for resource use from existing aquaculture species and community/industrial uses of water. Site availability is aquaculture's major constraint. Species value may justify the use of expensive technology (re-circulation) to overcome site problems but be capable of supporting the investment. There are some fish which will defy the model and put up with water temperatures and salinity ranges outside their tolerance. This is part of the risk analysis, the developer realises the fish is not living under ideal conditions. Therefore if problems develop at certain stages of the year or one year in ten or one year in twenty, it should not be a surprise. For example terrestrial agriculture in Australia, raising sheep. Many years pass with adequate rain, supplying enough grass feed then drought strikes.

3. There is nothing specific in new species development as opposed to ordinary aquaculture. It depends on the company's objectives. For instance for value fish it's worth building an expensive, intensive re-circulation system. If a species generates \$40-\$80/kilo re-circulation technology may be appropriate. It can go anywhere. A flounder company in Japan uses water out of a power station. If the developer uses water value and site availability in extensive culture there is no difference between a new species and an existing species, whether its salmon or one of the tunas. The new species is not an issue, but a confounding point.

Inland saline aquaculture will eventually be relevant but it needs a central organising body/group. It is not suited to mega enterprises, but is very well suited to a great number of small players, much like the salmon industry started in Norway. It can be set up in lots of small places but there needs to be a centralised bank of expertise which is unbiased and independent.

4. In Tasmania it would be a big issue because the existing sites already have salmon in them restricting new species occupation. But in South Australia with yellowtail kingfish everyone is keen for development including local government encouraging people to develop and acquire new sites. New species development may be easier in places like South Australia rather than Tasmania where established aquaculture has taken available sites. A new species developed in Tasmania would be either in, or close to an existing site currently used by salmon.

5. In Tasmania most of the available marine leases available are used for salmon, but no limit to pump ashore facilities. In floating cage culture a major new species would displace salmon production. Other States have similar restrictions on cage sites but little on pump ashore. This method or re-circulation might be the way in the future displacing the need for marine farms. The company's hatchery uses re-circulated water and holds 16 tonnes of live fish. Salmon is a problem because the volumes are so big.

If you found a species with a limited market and could grow and market 1000 tonnes of fish a re-circulating system placed close to the market could be OK.

6. Paramount. The Tasmanian industry is held back because of the inability of Governments to deal with such issues as water availability and their ability to see market opportunities. If a firm is using 70%-80% of the water under lease, governments may say 30% to go which is not much. Companies invest large amounts and have much infrastructure either in the water or on the land therefore security is needed to grow. There is increased competition for water in Australia, not just aquaculturalists but recreational activities, the general public, ascetic values. Water quality is a significant issue that needs addressing. In the existing industries legislative bodies take the easy way by monitoring a person they can see, potentially impacting that site, not at people who could have a significantly higher impact than the person using that site. For example hatchery facilities, the Government wants to impose world's best practice on a State that has a dozen hatcheries. There are issues of farmers and industry putting chemicals into rivers and yet none of that is monitored. Yet because the fish farmer is on the waterway and is seen to use the water, he is the person who will get punished. It's the same with environmental monitoring on sea cage sites. Some is good, other is worthless. They try to measure things and yet don't understand what other aspects can impact it. There are many aspects on land that impact the water quality in the water. It is too hard for governments and legislative bodies to measure yet they put the impost on the industry which sometimes is difficult to bear. Even though surrounded by water its not to say that a lot of that water is very useful when it comes to growing fish.

A selection criterion is how successful can a species grow in a specific area?

Can it be grown in several areas within Australia or overseas? Dependent on that will dictate whether that species is going to have a loyalty factor or novelty factor at the market. There are only two places in the State you can grow ocean trout, that's Macquarie Harbour and the Tamar River. There's not much room for expansion in the Tamar. Even if there is socially there would be big problems with expansion in that area and the same with Macquarie Harbour. People ask "do we want all these pens on the water and does that mean I cannot now go into that area." Cage sites in Queensland are difficult because of pollution off farms in Queensland, the sensitivity of the Barrier Reef Marine Park.

Summary

Site availability, water value and use

Site availability is aquaculture's major constraint and therefore of paramount importance. Requirements for, and properties of aquaculture sites, including the geographical location and environment for a species do not always fit a pre-determined model or are thought to be suitable for aquaculture. For example the Tamar River grows salmon and trout well and may be suitable for alternate species like snapper.

Some fish will defy the model and put up with water temperatures and salinity ranges outside their tolerance. This is part of the risk analysis where the developer realises the fish is not living under ideal conditions therefore occasional problems will arise as with terrestrial farming on the margins. The Tasmanian Government was proactive in assessing the Furneaux Group suitable for aquaculture and setting aside a potential site area if 760-770 hectares of water. Future operations there will be difficult, as are those on Bathurst Island in the Northern Territory. However this may in the long term be sensible as major problem with sites is competition from other water users. There is no difference between new species and existing species in site availability, selection water value and water use though in Tasmania possibly all sites are taken up with salmonids. New species either require new sites for example, yellowtail kingfish in South Australia or must displace currently farmed species. Opportunities for new species development may be in sites unsuitable for existing species or areas where all available sites have not been taken.

The ideal site has all the species-specific characteristics, but is also water nobody else wants, either at inlet, site location, outlet or all three. New species development may be easier in sites outside Tasmania unless the new species can grow in polyculture. Inland saline aquaculture with dispersed production units, pump ashore and land based re-circulation is a future options. Species value may justify the use of expensive re-circulation to overcome site problems but must be capable of supporting the investment. Re-circulation has the capability for location close to the market, significant comparative and competitive advantages.

33. If you were to develop a new species, would you use the same strategy used to develop salmon?

1. Yes. Because salmon was introduced, there was quarantine screening for disease and a hatchery development stage watching progress through smoltification. Then introducing small quantities to farms equitably distributed across the original players. A brilliant government initiative, the government drove and formed the hatchery, 51% owned by the government and private investors offered the opportunity to invest. Allocation of fish was pro rata to shareholding. The flagship company got too big too quickly and out of kilter with the rest of the industry and were given too many advantages. But a flagship company was needed.

2. Yes. Eels have been overlooked, but probably have global appeal of salmon and prawns. Eel is well recognised in Asia, Europe, and particularly Mediterranean Europe. Domestic market exists amongst Asian, Greek and Italian Australians.

3. Internationally no, domestically, yes. The way salmon grew probably was one off. The company is interested in rock lobster culture and there are similarities with the way salmon was developed in Tasmania. Government shareholding which gave it stability and good seeding finance, credibility, quota system for participation and an organisation with a monopoly for the first "X" many years to get it up and running. It was a good model we had and with a few modifications could work again for other species. Rock lobster didn't fly for different reasons. The wild fisheries sector was a problem basically. The Tasmanian strategy should be used again and should work again. But in developing salmon much technology was imported. The real question in terms of new species development in a place like Tasmania or any other State in Australia; "is the aquaculture industry better off grouping for strength or dispersing for survival?"

4. Yes.

5. Yes. Salmon started selling small volumes and ramping up slowly, a good way to sell aquaculture products.

6. Yes for trout, cannot speak on salmon. In hindsight the company would go about trout in a slightly different fashion, quicker and smarter.

Summary

New species strategy

Yes (5), Internationally no, domestically yes (1).

Internationally growth of the salmon industry was one off, but it produced the technology and species available for transfer and translocation respectively to Australia. The Tasmanian model with Government commitment and the establishment of Saltas was good and with some modifications could work again for another species. Development should start small and expand with the market.

34. How important were governments in establishing the salmon industry in Tasmania?

1. Vital. It was a Liberal Government initiative in Tasmania, the Grey Government. It was a whole government commitment carried on by an incoming Labor government. Sadly the "heart" has been dismantled, but is slowly starting to pull together again. The legislation which established the hatchery company had an R&D component.
25% of returns from smolt went into funding ongoing research into a range of nutritional, amoebic and other initial problems the industry encountered. The flagship company thought they were contributing too much because it was all pro-rata, paying per smolt and decided to dismantle it. It's coming back together through CRC projects and through other FRDC projects. The original R&D was crucial and fundamental. A core group of about four or five marine biologists dealt with the issues at government and quasi government level whilst working for Saltas and the R&D wing.

2. Pivotal in Tasmania. The timeframes for the set up are not political timeframes. Saltas at the propagation end of the industry was established under the auspices of an Act of Parliament with some good strategic provisions that allowed the industry to get set up.

Saltas was set up with a monopoly on production so other operators were not able to jump on the bandwagon, getting the boom bust cycle going in terms of supply. It was given that for a ten year period and there were examples from overseas at that stage where it was evident people were getting in and out of the smolt market and smolt supply as it suited them. Saltas was critical in getting a smooth run for the grower. The Act of Parliament had the proviso that Saltas must spend 25% of its gross revenue on R&D for the industry for a strategic process that allowed problems to be dealt with and provided a funding mechanism. The only weakness in the model was no one gave thought to what would happen at the end of the ten years. No one thought of the transition to free market.

Striped trumpeter has probably been persevered with too long but that is indicative of the political environment in Tasmania and a desire on the part of the Tasmanian government to have its own species.

3. Essential. Very important for generating interest, obtaining broodstock and funding research. The Government shareholding gave it stability, good seeding finance, credibility, quota system for participation and an organisation with a monopoly for the first X many years to get it up and running before passing it on to the private sector.

4. Very important in all areas of those initial stages. The salmon industry in Norway and Scotland was kick started by grants from the governments especially to individual operators. The Government gave percentage grants, 20%-40% of the initial capital at the start. The same with halibut, and with turbot in the European Union and Canada. Local governments are supportive of yellowtail kingfish in South Australia.

Government assistance helps because of the high initial cost and payback is a long way down the track especially new species.

5. Quite important. With legislation alterations for example, because it involved marine farm leases and hatchery sites, new legislation had to be drawn up. It included a joint venture with a Norwegian company.

6. Not asked.

Summary

Importance of governments

Vital (1), Pivotal (1) Essential (1), Very important (1), Quite important (1), Not asked (1).

The Tasmanian salmon industry depended upon the determination of the Tasmanian Government to establish and support a new aquaculture species. Government support was very important for generating interest, obtaining broodstock and funding research. The Government shareholding gave it stability, good seeding finance, credibility, quota system for participation and an organisation with a monopoly for the first X many years to get it up and running before passing it on to the private sector. The co-operative arrangement with Saltas allowed for a research and development levy of 25%. Government support also meant new legislation and changes to existing legislation to assist establishment of marine farm leases and hatchery sites.

Overseas the salmon industry in Norway and Scotland started by government percentage grants of 20%-40% of the initial start up capital. The same happened with halibut, and with turbot in the European Union and Canada.

Striped trumpeter has probably been persevered with too long but that is indicative of the political environment in Tasmania and a desire on the part of the Tasmanian government to have another new species.

Environment

36. When establishing, how did the salmon industry cope with environmental issues?

1. The environmental issues are an integral part of the way this industry was structured. Now the Marine Farm Planning Act, the Living Marine Resources Management Act that regulate all environmental impacts. It's been a steep learning curve. Aquaculture must present itself as an environmentally sustainable industry and work within those rigid parameters. The Tasmanian environmental model is now being used by other states and internationally and regarded as a defining model. It is management at the farm level and government-controlled in terms of stocking densities, nutrient input and feed issues are crucial. It's all very well to have great environmental controls, but if the wrong site was chosen they won't work.

From a commercial aspect there are clashes. The environmental monitoring division within the Marine Farming branch, headed by mostly PhD and environmental scientists has a mandate to control the issue from an environmental perspective. They would like to institute more regulatory control which is happening. There must be an appropriate balance here. Initially it was done on measuring outputs, measuring chlorophyll A levels, sediment samples, water quality issues. Total biological physical and chemical parameters are measured in terms of outputs from fish farms. Which is probably all that's needed. But governments would like to control inputs; feed quotas and smolt quotas containing the industry even more. Too much government control and regulation will choke the industry and stifle it. The company opposes feed quotas, but unless the industry takes the initiative and self-regulation works then the government has to fix it.

2. There weren't many environmental issues when salmon was starting. The scale of the industry was smaller and the environmental issues were more the affect of the environment on the industry. Hence the position the hatchery in the middle of nowhere, because it was sufficiently far upstream to be free of the influence of agricultural run off and irrigation use of the water. The only industry upstream is the Hydro and which in many respects that's a positive because of the storage of water is controlled with the flow of the river. With the grower sector of the industry more thought was given to sites which were convenient for the logistics of transport. They were the more important issues so the environment did not play a great role at the start. Professor Ron Roberts from Stirling University said in the early days that Tasmania was too warm for farmed salmon. Much of the development flies in the face of the conventional environmental requirements of the animal, never mind competing users of the resource.

3. In the early days the industry's effort in looking after it's own environment was more advanced and more sophisticated than the regulators. The industry developed faster than the regulators did, so it was not such a big issue.

4. When establishing the salmon industry didn't think of environmental issues because it was at a small stage with only a few cages. As aquaculture grows and becomes more established it potentially affects a wide area bringing environmental issues into focus.

5. There is a range of environmental issues, anything from visual impact through to uneaten food and faeces on the bottom of the ocean and seals. Some of those impacts aren't easy to deal with unless you have got an industry, some sort of a base line. The environmental side of salmon aquaculture grew along side the industry and no doubt got clues from what happens overseas.

6. Initially much resistance, but it evolved and the industry has seen the sense and learned from it. It is important for the industry to know what's going on and how it's impacting it, because lease sites are required for long term farming. That learning process and appreciation has grown and is seen as an investment, not to say that industry concurs with all types of environmental monitoring. Sometimes industry cannot understand why certain monitoring takes place. What is it trying to achieve? Environmental monitoring is not a cheap exercise.

Summary

Environmental issues when establishing

When setting up environmental issues were more the affect of environment on industry than *vice versa.* The industry's effort in caring for its own environment was more advanced than the regulators and the industry grew faster than the regulations. Both grew alongside and learned from each other, gradually adopting and adapting overseas techniques to Australian conditions. The learning process is seen as an investment, but there is concern that the regulators are now expecting too much. The Tasmanian environmental model is regarded as a defining model is now used by other states and internationally. Aquaculture must now present itself as an environmentally sustainable industry and work within the set parameters.

37. How would you now develop a new species taking into consideration contemporary environmental issues?

1. With finfish, the environmental impact is a function of fish diet requiring feed company input to develop appropriate feed. This company using steam pelleted pellets, has, with nutrition and feed formulation improved FCRs to around 1:1, maybe 1.2:1, which means a lesser impact on the environment than with the older diets and higher FCRs. Site choice is crucial, high current flow is highly desirable, so it's really matching the available environmental site characteristics to the right species with the right nutritional input.

2. Contemporary issues place more and more pressure on industry to have zero emissions making the bar for success higher. Species value must justify the extra effort.

That pressure is on all industries that consume or at the very least borrow water and return it to the environment in some kind of degraded form with increasing pressure to return the water in its borrowed state if not better. In some cases users have told the government that the water at inlet doesn't meet government criteria and asking how can the government ask for users to send it back in better condition. This climate will force more intensive use of water for example re-circulation technology which is expensive, therefore the farmer needs to get more value from the product by working smarter.

3. Contemporary aquaculture has two major environmental issues, interaction with seals and the ability to define what constitutes an acceptable impact on the environment. *The impact of aquaculture on the environment can be considered in two categories, impact on the immediate seabed, and addition of nutrients to the water column.* With improvements in the technology available pollution is more easily detectable in both categories. The question has not yet been asked whether a detectable impact matters. It may be better for society to allow an amount of impact as opposed to saying there should be none. That's the sort of risk aversion society has developed and it's translated here; the regulations have outpaced the development of the industry to the point of stifling it. The answer may be re-circulation systems, given increasing restraints on the quality of the water put back from aquaculture and impact on the environment. Also increasing conflict with other users of the coastline, boating, visual and recreational means aquaculture in Australia cannot be based on turning over big volumes of a cheap crop. Australia should focus on valuable species requiring a high degree of technology, because Australia can do it and other countries cannot. Then go for high quality safe food with consistent supply.

Multiple use of water is another environmentally friendly option. An example of multiple water use in central New South Wales is water from chalk mining applied to olive trees and the possibility of barramundi or eel aquaculture in the middle of the multiple use cycle.

The seals issue is different, a huge problem and the industry is not coping.

4. Environmental considerations are really quite high on the agenda with any new species as they are with the existing aquaculture species. Established aquaculture industries like salmon are dictating considerations for new species. For example cod and halibut development had to go through environmental reviews based on those required for salmon production which were not required for early salmon production. In Scotland with new species coming on like halibut and cod, all the environmental legislation is already in place because it's been established for salmon.

Market preference and acceptability are affected by customers' perceptions of food. It must be economically produced to make it affordable in an environmentally friendly way to make it acceptable. Ten years ago it would not have mattered so much about the environment. It would have all been economics, market acceptability and preference. But now environmental considerations are really quite high on the agenda with any new species as they are with the existing aquaculture species.

5. It's easier now because a lot of *the framework that's in place for salmon would also fit some other species* providing it's grown in floating fish cages which have the most environmental impact. A shore based re-circulation farm has less environmental impact.

6. Compared with ocean trout, when developing a new species more time is spent on the impact of that species on the environment from all aspects of the production cycle. *It's only going to become more difficult to grow fish in the environment standards set via the community for aquaculture. Those aspects can be of great advantage in the marketplace when selling that fish. How it is reared and its environment can have an impact on the image of the fish* and are a given in the assessment process. Can the new species be grown viably in that environment?

Summary

Establishing with contemporary environmental issues

Aquaculture impacts on the environment in two categories, impact on the immediate seabed, and addition of nutrients to the water column. Research and development into diet has done much to reduce both contributions. The equation is matching the available environmental site characteristics, preferably high current flow to the right species with the right nutritional input. Internationally and in Tasmania the salmon industry forms the framework of an environmental model adaptable for new species. In Britain cod and halibut were initially assessed on the salmon model.

In contemporary aquaculture the method used to grow fish and the environment in which its grown impacts on the fish's market image. How a new species impacts on the environmental and how the environment impacts on a new species are a given in the new species assessment process. A major issue is that the regulators in some situations require the outlet water or used downstream water to be in better condition than inlet or upstream water. The continuing demands of environmental regulators will encourage use of re-circulation technology.

APPENDIX FOUR
BARRAMUNDI RESULTS

Nothing in this world is so powerful as an idea whose time has come.

Victor Hugo, Legion d' Honneur (1802-1885)

French author, soldier, philosopher and revolutionary

Introduction

The interviews were conducted during June 2002; six in person at Bathurst Island, Darwin, the Northern Territory, and the Cairns region of northern Queensland and one by telephone. The interviews lasted from between one and two hours depending on respondents' available time and elicited responses from seven barramundi industry players. Players interviewed were a vertically integrated farmer, general manager, site manager, aquaculture centre manager, hatchery manager, an owner operator and a managing director who functions as a farm manager.

Results follow the questions in numerical order and the responses are rated and summarised under abbreviations of the questions. Where relevant, response frequency is recorded immediately after the questions followed by brief explanations based entirely on the respondents' words. In some cases, respondents provided answers to survey questions in areas of the interview other than in response to the question being asked.

New product ideas

1. How do you define a new aquaculture species?

1. One with the potential to make money and survive in the market place.

2. Has not been farmed before.

3. Has not been farmed in Australia, specifically the Northern Territory.

4. Barramundi isn't a new aquaculture species, *but it's a relatively new marine (mariculture) species.* A new species is one not farmed before. The company is trying *to apply the successful salmon model in a tropical environment* that will work in time.

5. An aquatic animal or plant that people are attempting to farm which has not been farmed before and may require breeding technology, husbandry and feeding bringing it into production, but not necessarily mean commercial production

6. A new species is one not produced over a certain level, say ten tonnes and subsequently adopted by industry players.

7. A new species is one not farmed but has the potential to be farmed.

Summary

Definition of a new species

A new species is aquatic fauna or flora that has not been previously farmed in Australia, but has the potential to be farmed profitably and regularly at, or over, an arbitrary tonnage and price to qualify it for adoption by industry players. This does not necessarily mean commercial production. Barramundi is not a new aquaculture species, but a new mariculture species dependent on successful application of the salmon model in a tropical environment.

2. Where do ideas come from for new aquaculture species and their products?

1. Entrepreneurial thinking by industry players, potential entrants or professionals.

2. Trade shows, conferences, players and overseas.

3. The market, industry enquiry, overseas, international and Australian journals,

4. From travelling, observing and thinking. Also business needs, in this case recognising the risks of the feed mill just supporting the Tasmanian salmon industry.

5. Market demand, suitability of a species for culture; ten different variables relating to ease of breeding, culture conditions, diet development. Supply potential markets with an aquacultured product on a more regular consistent quality basis than wild caught.

6. From anywhere, but generally market demand. The species should be initially investigated to ensure initial criteria of meat quality and cost of production are met.

7. From anywhere, generally starting with the market and working back.

Summary

Origins of general ideas for new species and products

Market (4), Industry players (4), Overseas (3), Entrepreneurial thinking (2), Trade shows (1), Conferences (1), Journals (1), Business needs other than aquaculture (1).

Ideas come from the aquaculture stakeholder environment, particularly the market but created by players at any stage in the chain and sometimes driven by business other than market interface with consumers, to wit, feed company investment in new species.

3. Where would you get ideas for new species and new products?

1. Market, species easy to breed and farm and complimentary species in polyculture serving as water or pond cleaners. For example mangrove cockle/ mud mussel/ Akul *(Polymesoda erosa* Lightfoot 1786) and milk fish (*Chanos chanos* Forsskål 1775).

2. Observing new species progress and technology problems and fisheries establishments and South East Asia.

3. International conferences and international journals.

4. Travel, journals and own resources to what I want to do personally. *The question is in Australia, what is the next new species?* It will be a tropical fish.

5. Alternate species suitable to grow in the same environment as current species without having to modify infrastructure significantly. For example the long finned or marbled eel *(Anguilla reinhardtii* Steindachner 1867). Eels entering the ponds for ten years have coexisted with barramundi and eaten the same feed. Watching, feeding, collecting and aggregating them in one pond produced a knowledge database.
The farm now deploys juvenile eel stock and has completed a one-year pilot study of barramundi and eels in polyculture. Eels like the environment and accept commercial barramundi diet, requiring little extra infrastructure and capital. The market is export out of Cairns to Hong Kong Chinese. Farm gate is double barramundi's, over 5 kilos is $14-$15/kilo farm gate, barramundi's is $7-$8/kilo, farm gate for a whole fish. The market in China is huge seasonal (Chinese New Year) and not well supplied.

6. The company's markets are restocking, supplying own farm and selling to other farmers. Queensland Department of Primary Industries analyses market prices and overseas developments, then rates potential species as A and B candidates often for re-stocking, a separate but growing market. For other species we analyse those suitable for our farm and markets for hatchery fingerlings.

7. Overseas.

Summary

Sources for individual ideas for new species and products

Overseas (5), Market (3), Journals (2), International conferences (1), Accidental species (1), Environmental species (1)

The question for Australian aquaculture is which new species will emerge from the range of the potential species? The results reveal unsurprising idea sources, suggest a tropical fish and reveal two additional sources of ideas, one accidental, and two, environmental new species. Respectively, long finned eel *(Anguilla reinhardtii*), an invading "accidental" species; mangrove cockle *(Polymesoda erosa)*, a water filter and milk fish *(Chanos chanos*), a cleaner of pond vegetation. Long finned eel has an established Chinese export market. Milkfish is under investigation for re-mediation of prawn and barramundi ponds and is popular with the Asian community. Mangrove cockle/ Akul, a bush tucker bi-valve popular with Aborigines is being developed for commercialisation in the Northern Territory. (Dr Richard C. Willan, Curator of Molluscs, Museum and Art Gallery of the Northern Territory, personal communication, 22 Aug 02). These secondary species can co-exist with current species under culture without the necessity for significant infrastructure modification. Mangrove cockles consume seston, milkfish eat aquatic flora and fauna, eels eat barramundi rations and anything else.

4. How would you appraise those ideas for new species?

1. Species value, known name, high growth, high FCR, fast cycle time, physiologically and temperamentally suited to mass production.

2. Need to farm? Market opportunity, differentiation, meat yield, ease of farming, disease susceptibility, ease of generating fingerlings, cost of production and profit.

3. Desk top review focussing on the species market appeal and possibly a preliminary trial of wild caught sample raised in culture with artificial feed.

4. Start from the market and work backwards. If a species has the right farming characteristics but is not known analyse its potential to be promoted. For example about 80% of products on the supermarket shelves did not exist ten years ago.
A barramundi has a big digestive system and frame. Recoveries are not much more than 40%, skinless, boneless, compared to salmon which is well over 60%.

5. Desk top review and trials understand the fish's market appeal, physiology and husbandry. For example barramundi was farmed for 20 years overseas before Australia.

Do preliminary studies to ascertain ability to breed in captivity, accept a diet or have one developed and suitability for available and potential sites.

6. Desk top review, on the market and current production techniques.

7. Market, hatchery, speed of growth, ease of growing and profitability. For example coral trout *(Plectropomus leopardus* Lacépède 1801) has strong market demand and can probably be farmed, but the hatchery cycle is too hard with low spawning numbers. Need a prolific breeder. Farms need stocking with required volumes when needed otherwise infrastructure is tied up. Nutrition can be modified during development.

Summary

Idea appraisal for new species

Market appeal/opportunity (7), Suitability for aquaculture (7) Desk top review (3), Known name (1), Preliminary studies/trials (2)

Central to the idea appraisal is there may be no need to farm a species because of adequate wild caught supply or an aquacultured species supplying a similar market category. Three respondents used the term desktop review to analyse the species market appeal, physiology, husbandry and production techniques. All these criteria were covered in the broad responses of the seven interviewees suggesting they would have used the term desk top review if familiar with it. The other respondents added ease of producing fingerlings, food conversion ratio and fast growth, suitability for mass production, differentiation, carcass yield, disease susceptibility and fecundity as appraisal criteria. Preliminary studies/trials refer to studying the species ability to breed in captivity, accept a regular or developed diet and *suitability for available and potential sites.* Alternatively, obtaining wild fish and growing them out in aquaculture conditions to measure their performance in culture and market as farmed fish, before investing. A new species need not already be known in the market.

5. *What sort of organisation is likely to develop a new species?*

1. Small-scale pioneering entrepreneur/farmer, scientific researchers or government. A big organisation may come in if the species shows potential.

2. A feed company with high market share and limited export opportunities to grow its own feed market. Adventure capitalists financing small or medium investors followed by corporate companies *when they see a lot of the groundwork has been done.*

3. Collaborative effort between government and the private sector with possible involvement from universities, for example barramundi and mud crab *(Scylla serrata* Forsskål 1775).

4. Wealthy organisation with vision. The company regards (Atlantic) cod *(Gadus morhua* Linnaeus 1758) as the alternative to Atlantic salmon and has the capacity, including feed mills and company vision to develop it.

5. Either individuals, investors or corporations. Several disasters have occurred with publicly listed companies, but industry people have the knowledge and scepticism.

6. Pioneers incur all the expenses therefore an existing company which can adapt its production techniques, operations and infrastructure to a new species. Fish are fish and many things are applicable whether it's one species or another.

7. An existing company with cash flow outside their new species parameter allowing no targets on production using R&D to develop the company and minimise tax. For example a large prawn company with established cash flow is experimenting on mud crabs without the need for short-term targets. The first success must be a trial with convincing results to enable establishment of parameters. Publicly listed companies put unachievable expectations put on returns, creating unrealistic projections to obtain funding. One publicly listed had good ideas and a state of the art hatchery but made ambitious claims to raise their share holding.

Summary

Organisations to develop a new species

Big company/corporation (4), Existing aquaculture companies (3).

Individual farmers (2), (Ad)venture capitalists (2) Collaborative effort (government/private sector/universities)(1)

Existing aquaculture companies not dependent on new species production targets or cash flow. Large organisations invest after the pioneering stage when the species is emerging, or in their own value chain, for example feed companies. Developers should not be publicly listed companies. They have a reputation for unrealistic expectations.

6. Is your organisation structured to develop a new species?

1. No. To develop a new species, we promote interest in it, seek external funding and do it through on farm applied research.

2. Yes. We have a huge international network to easily resolve issues and resolve problems, plus we draw on our own sea farming expertise and we have financial strength.

3. Yes. The aquaculture development unit has the structure to bring together appropriate people to undertake R&D as required.

4. Yes.

5. No. Lack capital and infrastructure. We developed a new species by default (long finned eels) at minimum cost.

6. Yes. Decent broodstock facilities are needed and expansion of the extensive larval pond for cheap failure-tolerant trial must fit in with barramundi, making progression slow. The company produced mangrove jack *(Lutjanus argentimaculatus* Forsskål 1775) and gold spot cod four years ago. Production was less than barramundi so the company stayed with the profitable barramundi. Other species will trial when they fit in with the barramundi which is difficult, with dry out procedures and the fish spawning times. The ponds can do barramundi and other species together. The best run with jack and cod was 10,000 but a run 300,000 of barramundi is the same effort. Barramundi do four runs a year on demand, the first two, October and December are the biggest for summer months grow out. The other two are spread out for the re-circulation farmers who grow fish all year round.

7. Yes. But not for several years because of recent upgrading to value add fish.

Summary

Organisation structured to develop a new species

Yes (5), No (2).

Developing a new species requires a high and broad level of interest

Those not structured to develop were rich in intellectual capital but lacked financial capital, infrastructure, capacity, resources, knowledge and experience, though one developed a new species by default. The "yes" respondents had most requirements, including one able to develop its own feed and source operational information worldwide. Two of those "yes" respondents may lack finance but have the knowledge, experience and guile to investigate and perhaps develop a new species cheaply.

7. Is your organisation currently investigating a new species?

1. Yes. Mangrove cockle as a "water polisher" and milk fish to clean vegetation from the ponds.

2. Yes. Cobia *(Rachycentron canadum* Linnaeus 1766) and a novel joint venture to improve southern bluefin tuna *(Thunnus maccoyii* Castelnau 1872) feed relying less on fish meal /oil by feeding pellets rather than pilchards.

3. Yes. Several at varying stages, prawns, high value finfish species and mud crab. Golden snapper *(Lutjanus johnii* Bloch 1792) (sea perch) is complete with closed the cycle and the technology is ready for independent development or a partnership.

4. Yes. Cobia in Australia and Atlantic cod *(Gadus morhua)* in Europe. Cobia has growth rates triple those of barramundi, 10 kilos in 14 months with recoveries similar to yellowtail kingfish *(Seriola lalandi* Valenciennes 1833) and cobia cages well.

5. Yes. Mangrove jack *(Lutjanus argentimaculatus* Forsskål 1775) is borderline (unlike long finned eel), yet to be proven in culture but is 75%-80% developed. Cost of production similar to barramundi now hence the producer will need a good price. Marketing could be a problem. Silver perch or jade perch are possibilities.

7. Yes. Milkfish has established breeding techniques. Superior growth, to a metre long, are white fleshed but bony. Broodstock are big and active requiring large water exchange. The re-stocking market is small prohibiting many developers. They are euryhaline and can be reared the same as barramundi. Potential species at 1000 fingerlings per pond for bio re-mediation, cleaning and stabilising prawn ponds enabling better production and with a good market as a secondary species in the Asian community domestic and overseas. Prawn farmers would expand the customer base. Re-circulation growers may be interested. Queensland groper is a marine fish which can live in an estuarine environment. It will take flushes of fresh water. Interest from restocking groups. Queensland groper is a better option than gold spot cod because of superior growth rate and price, is suited to the company's site, requires large broodstock, an advantage because not everyone can do it.

Big eye trevally *(Caranx sexfasciatus* Quoy and Gaimard, 1824). Euryhaline.

Cobia. Excellent growth rates and established breeding techniques. 4,500 tonne industry off Taiwan in sea cages. Freshwater flushes could be a problem, confident NT would like to try some. Prawn and re-circ farmers may be interested.

Barramundi cod *(Cromileptes altivelis* Valenciennes 1828) and mangrove jack. Mangrove jack is the second most requested fish for re-stocking after barramundi.

Gold spot cod=estuary rock cod *(Epinephelus coioides* Hamilton 1822)

7. Yes. Some of the grouper species for our saltwater Mourilyan farm which is under utilised but adaptable to most grouper species. Also mud crabs, breeding of which could be done in our barramundi hatchery. Groupers need partly saline to full saline. They are not euryhaline but can take full fresh for a week or two, but not a month or two.

Summary

Organisation investigating a new species

Yes (7). Cobia (3), milk fish (2), Queensland grouper (2), mangrove jack (1), gold spot cod (1), golden snapper (1), southern bluefin tuna (1), barramundi cod (1), mud mussel (1).

The species under investigation follow the pattern set by the origin and appraisal of ideas and organisations able to develop them. Two companies were interested in mangrove cockles *(Polymesoda erosa)* to filter barramundi pond water and milk fish (*Chanos chanos*) for bio re-mediation of barramundi and prawn ponds. Two companies were in cobia *(Rachycentron canadum)*. Cobia is successfully farmed in Asia, has a ready market and technology is available for transfer. Golden snapper *(Lutjanus johnii* Bloch 1792) (sea perch) was recently completed with technology available in Australia for uptake. Southern blue finned tuna *(Thunnus maccoyii)* in Australia and Atlantic cod *(Gadus morhua)* in Europe reflect a global company's desire to build a feed market and develop an alternate species to salmon. Prawns (several species) finfish (several species) and mud crab *(Scylla serrata)* are ongoing collaborative research. Mangrove jack *(Lutjanus argentimaculatus* Forsskål 1775) and big eye trevally *(Caranx sexfasciatus* Quoy and Gaimard, 1824) are opportunity fish which like milkfish have the bonus of being euryhaline. Silver perch and jade perch qualify as generic species awaiting market development. Queensland groper *(Epinephelus lanceolatus)* and barramundi cod *(Cromileptes altivelis)* are high value species with available technology from Asia and remain ready for further investigation.

These responses reflect a desire to diversify from barramundi, which is yet to be proven in Australia and only has the status of an emerging species.

8. How would you specify the design of a new product: what does a new product or species have to do?

1. Have the market qualities to serve an established or a potential market with the combination of production, price and a system with sustainable competitive advantage. A white or pink fish unique to Australia, attractive compared to what exists in the market, possessing an initial niche benefit of newness and new flavour and able to compete without a premium with some advantage in being produced in Australia. Australia should avoid global species. Overseas industries are more advanced, economic and competitive.

3. Make money, the economics of farming must be viable and the species aquaculture suitable and beneficial to the region.

4. An appealing taste, be acceptable in the marketplace and meet all the key performance requirements for culture.

5. Have strong consumer demand (which is very subjective), have potential amongst other products and fit into the value chain. *It must either have a place or be able to be placed in the market.*

6. Cheap production cost with a high end result. A species which has the eating qualities of coral trout and grows like barramundi! Hardy, euryhaline, avoidance of, or not needing to use chemicals, tolerance for high stocking and quick growth rate.

7. Start from the market and work back, looking ahead for the end result. Set up the infrastructure taking into consideration husbandry. Try emulating nature as much by doing on the farm what the species does or what happens to the species in the wild.

Summary

New product design

Mainstream industrial processes allow for a new product to be designed. A new fish species cannot be designed, but can be assessed under key design criteria or modified by genetic selection and hybridisation. The perfect fish is disease resistant, tolerates high stocking, grows quickly has the qualities of a new or appealing flavour and uniqueness to Australia. It must serve an established or potential market and fit into the agribusiness value chain, combining profitability with sustainable competitive advantage and competing without a premium. The species derivative products however can be designed to meet customer demands. One respondent highlighted the problems with domesticating any species, stating the perfect fish should have the eating qualities of coral trout and grow like barramundi!

9. How do you see the role of a product champion in developing a new product?

1. Vital. There is no substitute for the enthusiast.

2. Depends on the skills of the product champion. A biologist with no business experience may champion a fish that is uneconomic to farm.
Australia needs people who understand the business of aquaculture running and championing aquaculture.

3. Extremely important. One type is often a large company or a well financed individual who does the pioneering leading edge work prior to uptake. This is very important, risky, critical work and players often want incomplete technology which if released may increase investor risk, but if delayed may miss a major opportunity.
The other type is political support within government. Having a minister championing a species is important for action and resources.

4. Important and more than one is needed. Important to have strong clear vision and determination all along the way; need convinced management, marketers, biologists.

5. Very important to have a high profile product or organisations champion.

6. Important. A pioneer must get full benefit out of a new species therefore needs someone to promote the product. Next is someone who promotes it for the industry, not just a company. Jade perch in the early stages, received attention focussing on the good points. Two years later people think it is not such a good species after all. It hasn't got the market name or the taste to compete at the level thought.

7. Important. It's not necessarily the species, but the person behind the species. Existing champions will develop new species. New comers won't unless cashed up. Firms like Patrick Stevedores that have invested in Virgin Airlines, another "species." They have their mainstream of business with no expectations on things, can look long term and afford to carry it. Usually complete outsiders don't have a full understanding of aquaculture which is so different. Someone from outside won't start a new species, an existing company will, maybe not an Australian.

Summary

Product champions

Important (3), Very important (1), Extremely important (1), Vital (1) Depends on the skills (1).

It is not the species, but the person behind the species! Champions function in different skill areas at different levels. A biologist may champion a species but have no business expertise exposing the process to failure. Champions are effective working on converging axes. For example one doing the developmental work and another within government garnering political support. The Australian requirement is for multifunctional business aquaculturalists who are either convinced people or can convince, organise and direct management, marketers and biologists to promote the new species for the whole industry. Existing champions will develop new species though the danger is they will not realise the full benefits.

9a. How do you see the role of industry leaders in developing new species?

1. Important. But industry leaders are focussed on core business, production and chasing markets other than new species development, unless they have divisions set aside for NPD. Their role is helping and supporting those trying to develop new species.

2. Very important. Too often the species idea is sold by high profile, "good talking" visionary people whose concept is good but the planning is poor because they have allowed their visionary mind to go far ahead and forgot about the detail. An industry leader may produce the idea. He either has all the necessary development skills or is good in one aspect of aquaculture and a team player who can mentor and harness the expertise of a group with complementary skills throughout the chain from hatchery to market. Then analyse if a new species is a goer put it out to critique. Ten variables may be identified as development blocks, one or two may block but another eight variables not thought of will emerge.

3. Very important. Leaders have a better vision and a bigger picture of aquaculture and new species development. They think strategically long term, bringing together different components, identifying problems and enunciating the development path whilst educating and disseminating their vision to potential investors and existing farmers.

4. Important. Individuals developing new species must have significant capital. Businesses with just one product are vulnerable. A business needs diversity and vision.

5. Important. Someone with good experience and established knowledge in aquaculture, but pioneers often do poorly out of industries. A species suited to the same system and same environment enhances new species development and its imperative to work in conjunction with commercial production.

6. Important. It speeds up the whole process, but is not essential. A viable species will be taken up quickly.

7. Very important. They are the only ones who are going to do it.

Summary

Industry leaders

Important (4), Very important (3).

An industry leader has established aquaculture credentials and either has all the skills for new species development or is a team player who can harness the expertise of a group with necessary skills throughout the value chain. Leaders think strategically long term, identifying problems and enunciating the development path whilst educating and disseminating their vision to the team potential investors and existing farmers. For example ten variables may be identified as development blocks, one or two may block but another eight variables not thought of will emerge. Though leaders speed up the process, a viable species will be taken quickly.

New product screening

10. What should be the selection criteria for a new species?

1. The barrier of entry depends on the nature of the species and size of the operation. A small sedentary fresh water or estuarine fish which is easy to catch and spawn is one level of entry for a small operator for whom breeding a larger complicated species is difficult. Another level is a bigger fish which trials have indicated has potential with a potential big pay off requiring high investment. For example cobia is a fish a big company would take up on because they can understand its benefits.

Criteria are market demand and price structure of the species. If the species hasn't a market, assess its potential market based on its novelty and intrinsic qualities for marketability. Ease of farming; efficiency of production, adaptability to cage farming, high food conversion ratios (FCR), growth rate and quality of feed required. A fish which grows fast on a low quality feed with good FCRs is potentially a cheap meat producer. For example prawn food is more expensive than fishmeal but the end product is high value.

2. Profitability and uniqueness in a global market. Industry people must ensure potentially profitable species are researched, produce a plan with steps needed to prove. Analyse key decision points and decide a hierarchy of scores. Establish disease vulnerability, ease of producing juveniles and fillet yield by visiting another country, feeding the information into a business model and checking its accuracy. Does it still stack up? Taste test fish. Is this fish better than other fish? An initial option is to obtain wild fish at a specified size and trial them in cages before going to the expense of closing the lifecycle. For example with a species like snapper if the business plan is based on turning those fish off at 500 grams after 12 months at sea, the best decision might be to catch 1000x100 gram fish, clean off the parasites, put them in a sea pen and see how they grow, rather than spawning them first. The selection of new species will change as production technology changes. For example the operation of a recirculation system next to Osaka markets would be governed by availability of eggs all year round flown in from anywhere in the world. A State or National body of people with the skills should analyse what is the best species for each State against selected criteria.

3. Start with the market and profit potential then work back through the technology to see what's known now. Predict investment return in 5-10 years time and analyse risk management in the chain from broodstock holding, husbandry, larval rearing, juveniles' feed development and site location. Queensland has no sites because of the Great Barrier Marine Park Authority. The NT has not that constraint so sea cage industry development can proceed. Technology, sites and all other criteria need ticking off through the production and marketing phase. Freight costs may make a quality fin fish unprofitable.

4. Market (taste, looks and shelf life) and ease of farming, closed life cycle and ability to produce fingerlings. Acceptable but not necessarily well known. Good recovery or yield. Barramundi recoveries are about 40%, compared to salmon which is over 60%.

5. Possibly ten different variables. Start with the market and work back to ascertain position in the market place, potential marketability, potential market price and which segment of the market to be targeted by commercial production; wholesale, retail. Suitability for value adding to offset inevitable pressure on farm gate prices. Suitability for farming including its ability to handle environmental change or its limiting factors in relation to where it can be farmed geographically. Suitability for breeding and diet development and whether it can be farmed in existing facilities or whether it requires completely new infrastructure.

6. Market size and price for the selected species. Ease of production; the ability to eat artificial pellet, hardiness, euryhaline is a bonus, high stocking densities, quick growth rate. Each potential species is different, weak in some areas and strong in others, therefore a system of grading against each selection criterion must establish a scoring hierarchy. The result is a checklist of variables not all of which can be achieved. Those which cannot need to be "managed around." For example, often a new species lacks an existing market but if it meets all other criteria, good promotion may overcome this deficiency. A key attribute for selection criteria is site availability. *Lack of sites inhibits production of some species,* for example coral trout and barramundi cod need high quality water, available only on the outer Barrier Reef where there are no sites or in re-circulation systems, most of which haven't access to saltwater. The other alternative is prawn farms which may not have good enough quality water.

7. Initial consideration requires an adequate market, acceptability in the marketplace and knowledge of husbandry and hatchery cycle. For example about 3-4 years ago the company put in a couple of tanks of barramundi cod broodstock. With manipulation in a very short period of time barramundi cod spawned. At the first spawn, eggs were fertilised and were watched the go right through in the best conditions. Barramundi usually hatch in about 17-20 hours. After about 20 hours the eggs were only partly developed. With the barramundi experience it seemed the eggs were not going to develop, so they were dumped. One month later another spawn occurred on the moon cycle, with the same result and the eggs were dumped. On the third month a third spawn occurred and the same thing happened, a small spawn and the egg collector was accidentally left in the broodstock tank. About 45-48 hours later there was the small number of eggs were still in the egg collector which was giving them good aeration and good quality water. They were maintained well and after about 48 hours, were noticed about to hatch and under the microscope a few were seen hatching. Only about 20-25% hatched. The barramundi cod eggs took 48 hours to hatch whereas barramundi was 17-20 hours. After 17-20 hours the barramundi cod eggs were less than half developed and possibly no good. Therefore two lots of perfectly good barramundi cod eggs were thrown away, no one in Australia knew the eggs take 48 hours to hatch. Since then the company found out from overseas that's a regular occurrence. A developer cannot go on re-inventing the wheel. For example Northern Fisheries are doing flowery cod. About two years ago flowery cod were in spawning condition, but everyone wanted to go home for Christmas. It was put off until after Christmas but later found that flowery cod has only got a window of opportunity of six weeks for spawning. The staff came back to find the flowery cod had gone out of spawning condition. A whole year could be lost by not knowing and in the barramundi cod case that was the last spawning available from that broodstock for about nine months. Were those vital bits of information and followed it through the company may now be doing something with barramundi cod. All the broodstock went to Queensland Department of Primary Industry so someone else could improve the knowledge. The husbandry of the fish must be close to established species aquaculture by the company or have an adaptable technology. The developer must find out more about very closely biologically related fish. For example different types groupers are produced world wide because the family has a similar husbandry and the hatchery cycle known. The Queensland blue grouper has a similar life cycle to the Asian groupers so Australia could adapt that technology; its reproduction system, the life cycle for larval production, hatchery cycle and nutrition. With correct marketing a premium price is achievable because of Australia's clean and green image. Two years ago Asian groupers brought $US12-$US18/kilo. The Queensland blue grouper should bring $25-$30.

Summary

New product selection criteria

Market demand (4), Profitability (3), Ease of farming (3), Able to have a diet developed (3), Closed lifecycle (2), Ease of producing juveniles (2), Recovery rate/fillet yield (2), Good growth rate (1), Robustness (1), Uniqueness (1), Globally competitive (1), Potential for value adding (1,) High FCRs (1), Disease resistance (1), Site availability (1), Knowledge of husbandry and hatchery cycle (1), Euryhaline (1).

Whereas idea generation initiates the agribusiness value chain, the results of a screening process open the point of entry to the chain, a barrier that also depends on the nature of the species and size of the operation. For example commercialising a small sedentary euryhaline herbivore requires a different level of approach and investment than a large marine carnivore.

The general response was to start with the market and work back assessing if the fish can be produced at a profit. The marketing projected inwards should, on a linear plane meet the technology travelling outwards, reaching a point of balance which indicates an enabling or disabling production><market equation. The market dictates size, price and possibly cold chain operation. Market location is also important. Ease of

farming means ease of fingerling production, adaptability to impoundment, high stocking densities, ability to eat artificial feed at varied levels of quality, high food conversion ratios (FCRs), hardiness, fast growth rate and resistance to disease. Also good fillet yield, for example barramundi recoveries are about 40%, compared to salmon which is over 60%. The husbandry of the fish must be close to established species in aquaculture by the company or have an adaptable technology. The characteristic of euryhalinity is a bonus. A selection criterion is species suitability for existing sites or potential sites. Few sites are left and lack of sites inhibits production of some species, for example coral trout and barramundi are restricted in Queensland by the Great Barrier Reef Marine Park.

Ideally four activities could run parallel in the candidate species screening process. A desk top review, a taste test by selected food panels, a trial run caging wild caught species to ascertain their performance in captivity and a scan of the international scene to establish a database on the candidate or similar species to test the selection criteria and project potential profits.

This work forms a model for new product development which incorporates selection criteria, financial analysis and risk management in the chain against stage gates at which the question are asked; has the product satisfied stage gate criteria, if not why not, is more work needed or the species abandoned?

11. Do you think these criteria are generally applied?

1. Not applied systematically, requiring a gap analysis. The criteria has to be holistic, the whole being greater than the sum of the parts. The market is the start point.

2. No. New species are generated by biologists not business people. The first batch of fish earns a big price because it's new. When industrialised the vogue-premium flavour fish falls from the unique category into the quality market and if not controlled it falls again into the price market. Gaining and maintaining a top price is everything.

3. Yes in the region, but no Australia wide. Only a few species under examination will come to commercial outcome and had selection criteria been properly applied many species under investigation would have been screened out.

4. No. For example striped trumpeter, a tasty fish, unknown outside Tasmania. They domesticate and handle impoundment easily, but hatchery is a problem. Recoveries are probably similar to barramundi, but the current price for wild caught is low. Hatchery and market are yet to be proven, therefore a business cannot take up on striped trumpeter.

5. In Queensland only some criteria have been applied. Market analysis (domestic and export) is a critical but left out. Often the evidence collected for new species is anecdotal with little quantified information and only small surveys. Australia has the best seafood of the developed nations, but we probably consume least per capita. Japan is ahead of us about 10:1. It's production growth and export potential is critical. Appraisals of new species like silver perch and jade perch are typical examples in Queensland. Little is known about jade perch. Silver perch *(Bidyanus bidyanus* Mitchell 1838) is a similar fish and selection criteria was; grows as well as jade perch if not faster, is mostly omnivorous, hence low feed costs and tolerant to extreme conditions so it's assumed to be a good candidate. But no market presence and market acceptability is the critical work for new species. A percentage R&D should go a species market survey. Many new species are picked for their potential marketability or their potential to substitute for similar species. For example sleepy cod *(Oxyeleotris lineolata* Steindachner 1867) in North Queensland is similar to a marbled goby highly valued in the Asian live trade. The logic was that sleepy cod could be produced and sold for $70/kilo live in Hong Kong. But sleepy cod grow slowly, cannibalise and have issues early in production and breeding and therefore not proven for aquaculture. Product value when entering the marketplace is a major consideration. For example a reasonable tasting, but not outstanding freshwater fish enters the market place with considerations of where it fits in and its potential value.

6. Yes. Factors are overlooked or values underestimated. Much is guesswork.

7. Yes, there are criteria but I don't think the research institutions are doing it well. They look at it from their own point of view. A typical example is Northern Fisheries and mangrove jack *(Lutjanus argentimaculatus* Forsskål, 1775) which will never happen in Australia. It hasn't got a high value market. Very few of the *Lutjanidae* (sea perches) family can be used for aquaculture because they are worth less than many existing aquaculture species. Many species are easy to do for example golden snapper but overseas they are worth less than barramundi. DPI are working with mangrove for restocking impoundments but not enough is known if it can sustain in freshwater.

Summary

Selection criteria applied

Yes (2), Yes and no (1), Not applied systematically (1), Only some (1), No (2).

Both "yes" answers qualified their responses by stating sometimes factors are overlooked or values under estimated and research institutions look at new species development only from their own view point, "Only some criteria applied" meant market analysis both domestic and export was left out. The "yes" and "no" respondent argued that in the region selection criteria was properly applied but not Australia wide, commenting that if it had many potential species would have been screened out. The 'no' answers were concerned that biologists not business people generated new species development and a correct new product development process including the business was not followed. Striped trumpeter appears driven by some business and some science satisfying selection criteria of taste, uniqueness, ease of impoundment with recoveries probably similar to barramundi. But though the lifecycle is closed, production of quality fingerlings remains a problem and the current price for wild caught striped trumpeter is low and the fish unknown fish outside Tasmania. A company cannot take up striped trumpeter because years of research and investment have not produced substantial *curriculum vitae.* Product value when entering the marketplace is a major consideration.

12. Do you know of potential new species being poorly screened and subsequently developed without proper assessment?

1. Yes. Golden snapper *(Lutjanus johnii),* also known as fingermark sea perch, a nice fish and popular with local amateurs but brings only half the price of barramundi in the southern markets. DPI received funding and spent years developing the fish eventually visiting Thailand for the technology that came down to a particular copepod. They found they could spawn them easily and raise them. After millions of dollars they have a shaky technology which sometimes allows them to raise these fish with a half reliable method of raising the copepods they feed on. DPI said golden snapper is similar to barramundi and could be done easily but no one wanted their fingerlings. They then said it is really an analogue for a reef fish because it uses the acadia copepods needed grow reef fish. Now it's barramundi cod, so they are drifting into another species but its lifecycle is closed at Gondol in Bali. DPI are pretending they are doing innovative work but did not investigate the market properly first. There was no demand as the Asians grow large amounts easily, therefore no real potential for golden snapper export and no price for them in Australia. Also wild caught golden snapper are numerous in Asia. Barramundi cod, is difficult to farm and even if successful the Asians are not interested in barramundi cod juveniles because they considered not to be worth the trouble to farm. Also mangrove jack *(Lutjanus argentimaculatus* Forsskål 1775) in Queensland. Queensland is setting up an operation to grow reef fish, but people who have access to saltwater grow prawns not fish in ponds. The Great Barrier Reef Marine Park Authority prevents any cage culture. The Gulf of Carpentaria may be a future opportunity.

2. Silver perch is a classic, driven by biology on the basis of "we've got to produce more fish in Australia because we are importing so much." *Australian aquaculture should produce a high fish it is good at and import fish it is not good at. Producing low priced fish is something Australia will never be good at. We don't have the water resources.* Others are Murray cod *(Maccullochella peelii* Mitchell 1839). It keeps a re-circulation system viable because it has a good profit margin, but will never be scaled up because it takes too long to grow. A species must have the individual criteria of easy eggs, easy juveniles, short growth period and high density stocking because cubic metres of water are being farmed. Redclaw *(Cherax quadricarinatus* von Martens 1868) failed because it was biologically driven. Snapper is not going to be a highly profitable species. It can only be farmed in a water temperature from New South Wales to Brisbane. Re-circulation systems on land are currently unviable and there are no saltwater sites available. Golden snapper is a good quality fish. The hatchery can produce juveniles but not reliably. The company was to trial 20,000 golden snapper, but it has a lower fillet yield than barramundi and earns $8/kilo. An ideal target species returns a 30% net margin justifying the pioneering. At this stage the company needs $8-$8.50/kilo. Fully industrialised it needs $6-$6.50/kilo to get a fillet into the supermarket wholesale @ $15/kilo to retail @ $19/kilo, people won't pay more than $20. To pioneer this project @ $6-$6.50/kilo couldn't be done because pioneering costs are so high.

Striped trumpeter is unique to Tasmania and an alternative to farming commodity salmon competing with Norway and Chile. The only advantage the Tasmanians have is freight costs, but if frozen fish are the market the freight value becomes very small. With fresh fish on the market you have a higher fresh margin to work on, a higher price difference. Tasmania will get squeezed because globally there's hundreds of thousands of tonnes available anywhere in the world, so they need another species. Striped trumpeter lacks information on production cycle, 12 months or 2 years? Suitable growth rate with an acceptable fillet yield? Can 5,000 tonnes be produced for an equivalent fillet price of

$15/kilo into the supermarkets? A new product development process has not been correctly followed. It's another biologist driven species. It needs a mix of expertise, stage gates and a logical time line. Certain things have either got to happen or answers have to be available for why they didn't happen in that development process.

Yellowtail kingfish *(Seriola lalandi* Valenciennes 1833) in South Australia began because somebody could produce the juveniles. There are 1200 tonnes of fish sitting in the water with the industry wanting to grow to 5,000 tonnes. They have two big issues; where to sell them, who will buy them. The second one is four months of the year they don't grow, because it's too cold in South Australia. They continue to eat (a reduced amount) which pushes the cost up. The company started working with the yellowtail industry in July 2002 to try and market some of the fish for them, because it's a feed supplier and we want it to grow, but they are having trouble selling. (Barramundi has the name, but the market does not recognise yellowtail kingfish). Their price expectation is too high. Because their feasibility study predicted $11-$12/kilo, but this is unprofitable working on fillet yield. Now they think $8-$9/kilo because their costs are so high, but the reality is $6/kilo. There is investment, meaning infrastructure development, therefore possible overcapitalisation. In contemporary sea farming the global companies can say how much per kilo it will cost for labour and all other criteria. Yellowtail was another one where again the initial feasibility was done by a State fisheries department on the basis of a biologist saying we can produce this species. Someone from a business department puts a business plan together which says 26% ROI on the species. Investment comes from someone who is a goer, an entrepreneur, because that's what usually happens, venture capital comes in and they find out the reality is not there. There are species which are developed without a plan. The tuna industry developed without a product analysis. There was probably very little product analysis done for the salmon industry. There was a captive market which knew the fish. Barramundi has survived by people buying plate-sized fish for $10/kilo. It now has to move into a fillet which is a different price point.

3. No.

4. Yes. Barramundi cod *(Cromileptes altivelis* Valenciennes, 1828) and golden snapper. Both poorly screened with resources directed to the fish without the homework.

5. Yes. Sleepy cod and mangrove jack. R&D resources and allocation are a problem. Often a restricted amount is available for new species and is allocated accordingly, overlooking critical areas. Both species had little money and were targeted over other species for barramundi farmers in the last 8-10 years. Limited success of early R&D work meant support waned. Mangrove was not picked up by industry and their only hatchery switched to more profitable work.

6. Yes. Not sure whether jade perch it was poorly screened, it has potential but outstripped the existing market. Its commercialisation needs modification by either reducing production costs or finding different markets. An error of judgement was made with coral trout. The market was organised but the production wasn't. *Screening wasn't done to ensure that production could be done successfully.* Overseas the lifecycle for barramundi cod is closed. The company did better than expected. Anecdotal evidence suggests they got 900 barramundi cod fingerlings through to 100 mm. The hatchery people had a success and the production people were ahead of where they should have claimed to be. Management failed them. This is an example of where the new product development process wasn't correctly applied. Coral trout may still not be a good candidate because it requires such high water quality, limiting stocking density or have very high running costs to produce it. The developer may be better off going down the chain of market prices to a lesser value fish but make a higher profit.

7. Yes, mangrove jack, mulloway and mullet species haven't got a high enough market price. $8-9/kilo is needed.

Summary

Species poorly screened

Yes (6), No (1).

All the "yes" respondents said science driven, rather than market driven new species development is a major problem for Australian aquaculture.

The following species were identified as being poorly screened and subsequently developed: Golden snapper (3), mangrove jack (3), Mulloway *(Argyrosomus hololepidotus* Lacépède 1802), mullet species, silver perch, Murray cod, sleepy cod *(Oxyeleotris lineolata* Steindachner 1867), snapper *(Pagrus auratus* Bloch and Schneider 1801) and yellowtail kingfish *(Seriola lalandi* Valenciennes 1833).

Neither barramundi cod *(Cromileptes altivelis* Valenciennes, 1828), nor coral trout *(Plectropomus leopardus* Lacépède 1801) fit the category of being poorly screened and subsequently developed. Both species passed an ad hoc screening process that incorrectly grouped them together. Barramundi cod's lifecycle is closed in Asia where it is plentiful and coral trout's is yet to be closed. Though a strong market exists for coral trout, sites are a problem, as it requires high quality water. These are probably future potential species.

Generic problems were; "re-inventing the wheel," a phrase used many times describing reluctance or inability to import technology, closing the life cycle, high price expectation but low market price, slow growth, low yield, cannibalism, geographical restrictions (snapper). An ideal target species returns a 30% net margin justifying the pioneering. Using marine farmed barramundi as an example, the company needs \$8-\$8.50/kilo. Fully industrialised it needs \$6-\$6.50/kilo to get a fillet into the supermarket wholesale @ \$15/kilo to retail @ \$19/kilo. To pioneer this project @ \$6-\$6.50/kilo couldn't be done because pioneering costs are so high. \$8-9/kilo is needed.

Many new species are picked for their potential marketability or their potential to substitute for similar species. Silver perch should have worked; mostly omnivorous, hence low feed costs and tolerant to extreme conditions so it's assumed to be a good candidate. But no market presence and market acceptability is the critical work for new species. A percentage R&D should go a market survey of the potential species. One respondent saw limited future for the *Lutjanidae* (sea perches) family because the species cannot attract high enough market prices. But some species are developed without a without a product analysis or plan for example salmon and tuna. Both fish had the advantage of being known in a captive market.

The new species development process must have stage gates at which objectives are achieved or explanations available for non-achievement. This process requires correct allocation and concentration of resources.

13. Should fish farmers examine the possibilities for new species as ongoing business research, or expand production of already established species?

1. Both. Industry focus will be on improving the husbandry and genetics of established species. However a novelty species is scarce and therefore has a good price.

For example a farmer in NT is getting $14/kilo for native bream. Opportunity exists to establish a new species in a new area, for example inland impounded irrigation water. An established species is appropriate if a producer's volume capacity is limited or there are no suitable new species. A new species may provide options but it's a high-risk strategy because of R&D costs and if successful provides a temporary window for the developer before being bought out or flooded by the same species grown elsewhere cheaper. Increasing momentum established species increases the barriers of entry for new species. Cobia is a big fish suitable for fillets and possibly plate because their high growth rate reaches half kilo size quicker than a fish with a maximum growth size of 2 kilos.

2. Both. Concentrate on established species to survive long term and monitor price points and stimulate ideas on what new species should be developed. Pioneering development is best done in Australia by the State fisheries organisations, but they choose species they want to work with, not necessarily ones that will be profitable. In Australia fisheries research institutions are driven by the biology of hatchery, because new entrants are good hatchery technicians not business selection expert hence the decision makers have come through that chain.

3. Both, depending on the circumstances. If the market for the current farmed species is limited then invest in future development and expansion.

4. Both, depending on the circumstances. Consolidate and do well, then examine financing alternative opportunities. The Northern Territory Government is currently doing a five-year road map for future aquaculture. A lot of that initial work will be taken up in that strategy.

5. Both, it goes hand in hand. Aquaculture in Australia is a new and evolving and parts of that whole process is examining what else can be done with existing facilities like trying a different (new or alternate) species. But diversification may be into product development and value adding, *so not developing a new species but diversifying what is already being done.* It must be a co-operative effort, but options for barramundi farmers to grow new species are limited.

6. Both, depending on the individual company and their financial situation. The company should do an existing species well before looking at a new species that requires DPI assistance, the right staff and motivation. There are few freshwater options.

7. If existing markets can be expanded, then increased production is first choice, provided it's profitable. If existing species cannot be expanded a new species is the next option, but first look at existing product options.

Summary

Expand existing species or develop new species

Both (6), Stay with existing species (1).

Three respondents noted that either option depends on the company's circumstances and financial situation, suggesting concentration on established species for survival whilst scanning for new opportunities, particularly if the current market is limited. The evolution of aquaculture in Australia means examining alternatives for existing facilities or developing a *new species in new areas.* There are few freshwater options for new species therefore barramundi farmers' choices are limited and diversification may be into *new product development* and *value adding* from a species already farmed.

14. What attributes should an aquacultured fish have to survive and thrive in the marketplace be it domestic or export?

1. Ease of farming from breeding to harvest, efficient FCR and growth rate. Good storage capability and shelf life. Barramundi is a good species.
Tolerance of environmental extremes gives range and flexibility. Disease and parasite resistance has economic importance and reduces exposure to crashes. Reliable supplies even if seasonal. Reliability builds the market place and preferably continuous supply. An established name and consumer identification with the product. Desired market qualities. If a fish with different qualities is introduced *there will need to be a promotional period that may not work.* Fashion and adopting what people eat in other parts of the word can change culinary taste for example sashimi raw tuna made the species valuable.

2. Price point and desired markets either the top market or one of the series of those underneath it. Economic production in the best location domestically and internationally. Physiological characteristics of shelf life and pin bones. Australians want boneless fillets so if the new species has pin bones they must be removed. Long shelf life gives a range of options, road freight instead of airfreight and people in the chain have longer to sell.

3. Market acceptance and a consistent price to enable farm development based on receiving a good price throughout the year. Shelf life, processing options, value adding as the industry expands for example salmon. Volume is necessary for economies of scale and to develop market chains unless filling small niche market.

4. Taste good, look good. Different species have different markets and shelf life.

5. Consistency in physical attributes and quality. *Consistency is one of the critical factors for long term product survival.* Flexibility of use and shelf life. Existing market.

6. Eighty per cent marketing, promote the product and make a relatively ordinary fish present well. For example catfish in the USA was pushed and it found the right avenues, production costs are down low enough for the species to squeeze into that market. Barramundi is at the crossroads for major changes. Saturated the plate market and people are going into bigger fish, but a whole large fish has a limited market too.

7. Market acceptance. Fish have a market *with people who want that fish, be it salmon in Australia or grouper in Asia.* Value adding and promotion.

Summary

Surviving and thriving in the market place

Market acceptance (7), Shelf life (5), Flexibility (4), FCR (1), Tolerance of extremes (1), Disease resistance (1), Appearance (1), Taste (1), Reliability of supply (1), Consistency in physical attributes and quality (1).

Enabling qualities for surviving and thriving in the market place were divided by respondents into market and production attributes. The most common attribute identified was shelf life. Barramundi as a whole fish on ice lasts for three weeks if not processed, allowing flexibility of use and processing options. A long shelf life gives a range of cold chain options, road freight instead of airfreight and more time for chain players to handle and sell the fish. Fish have a market with people who want that fish and the Australian market wants white fleshed boneless fillets. Other marketing qualities are an established name, consumer identification with the product and price point. Using the catfish example, one respondent noted that 80% of survival was marketing to (if necessary) make a relatively ordinary fish present well. Changing fashion and adopting overseas culinary tastes can change demand. For example tuna a second class species made valuable by sashimi. An introduced fish with irregular qualities will need a promotional period that may not work. Farming attributes are efficient FCR, growth rate, disease and parasite resistance, tolerance of environmental extremes giving a species range and flexibility

Attributes applicable to both marketing and production are consistency in physical attributes and quality, a critical factor for long term product survival and reliable supplies, which build the market place, preferably continuous, but acceptable if seasonal. Also economic production in the best location domestically and internationally. Volume is necessary for economies of scale and to develop market chains unless filling small niche market. These with market acceptance and a consistent price enable farm development based on consistent revenue throughout the year.

Barramundi is at a crossroads for major changes. The plate market is saturated necessitating a move into bigger fish, but a whole large fish has a limited market too. The next logical step is following the salmon model of value adding as the industry expands.

New product marketing

15. Where is your market?

1. A whole fish niche domestic market in Australia with top restaurants in Sydney and Brisbane and exporting about 50% mainly to the United States. All product is sold through agents and both the domestic and export markets are evolving.

2. Whole fish, domestic and export, but the domestic market is saturated with poor quality freshwater barramundi. The market wants boneless fillets from sea grown fish or better quality, cheaper freshwater fish and to get a wider market appeal. Export builds on the Australian image in both Germany and America. The target is 50%-80% export with 80% preferred as it's more profitable. To grow 5000 or 10,000 tonnes a good domestic base is needed and a lower the price to expand the market. Currently (19 Sep 02) producing 8 tonnes/week landed whole in the markets for $8.50/kilo.

3. Cooked prawns to southern markets and marine barramundi to local markets. The Australian market is very small and there are major opportunities to produce at an internationally competitive price. Long term growth of aquaculture here is export.

4. Australia, but eventually majority will be export to the USA and Europe.

5. Predominantly domestic, East Coast Australia and local (Cairns) wholesale, retail and restaurants with 10%-20% on a daily basis if necessary. 50% goes to Sydney which is both wholesale and retail and some restaurant trade. 25%-50% sent to Sydney goes through Seafarmers which then goes through a wholesaler. Of the remaining 20% some goes to Melbourne and some is exported. The export is inconsistent. It may go for a few months then stops. Seafarmers have markets developed in the US which they are trying to service on a weekly basis. The market is predominantly for large fish, but possibly looking for a market for smaller fish. The farm gate return is ordinary at $7/kilo for what Seafarmers are offering. They are working on a 5%-10% margin another farmer gets $7-$7.50. They pay freight and if bulked packed is reasonable price. Using styrenes is another 30-40 cents/kilo. 80%-90% is sold on the East Coast. We air freight more than 50% of our product to Brisbane, Sydney and Melbourne but we increasingly use refrigerated road freight because of the cost and barramundi does have a very good shelf life. Most goes whole chilled. Some processing, gill gutting and scaling and some filleting on site. The company is trying to develop new products with plate sized smoked barramundi, using an export registered privately owned smokehouse off site. Smoked fish returns $15-$20/kilo. It's well accepted, going well in local restaurants vacuum packed with a shelf life of 3-4 weeks and can be eaten at room temperature or chilled. *Diversifying some plate-sized product away from our reliance on the Sydney wholesalers and retailers* and supply the smoked market. The smoked product is working on a farm gate return of $9-10/kilo for the whole fish which for plate size is a viable return. If controlled the company's offering to the smoked market will enable sustained production of plate sized fish. There is a need to work away from reliance on the wholesale trade. Fish are sold through an agent with 20 other barramundi farmers. None of whom are happy because the price keeps going down. Production in the next 12 months is predicated to go 40-50 tonnes/year. The break up is a percentage of large fish, 10% over 2 kilos. 10% will be eel production and the other 80% barramundi under 2 kilos and of that 80%, 60-70% will be under 1 kilo. Market price for small barramundi has been poor in the last 6 months. A lot of the expansion is in large fish and many people are hoping this is the case. The market for plate sized fish should stabilise and the price won't drop any further. Some players produce only large fish and we do have some other large players targeting large fish production but are now selling all sizes because of their inability to sell one specific size. One farmer sells all sizes of fish because his production rate has to be around 15 tonnes/week to break even. That coupled with some increased production in plate sized fish means we have flooded the domestic market for the amount of demand that's there.

6. Ninety per cent domestic and the company does its own marketing and promotion in Melbourne. *The (competitive) advantage of saltwater fish is more saltwater fish can be* *sold at a similar price than freshwater fish. The market prefers saltwater because it perceives them as better.* Marketing is pushed on the saltwater advantage. Some export.

7. Forty per cent to the traditional wholesalers and the rest to the processed market of set weight portions and fillets and cutlets to supermarkets. Export to European countries in the higher value market. Marketing name is King Reef Barramundi, named after a reef near the Mourilyan farm which has deep water access to the sea.

Summary

Market location

Markets are well segmented with producers catering for the domestic wholesale, retail and restaurant market. Producers are flexible reacting to the decline of the plate sized fish market with a bigger fish up to 3 kilos suitable for filleting. They also identified a need to move to move from reliance on the wholesale trade, because the price keeps on going down. The much vexed question of freshwater versus marine barramundi arose. Respondents continually identify the euryhaline characteristic in a species as a bonus. This means that whilst ever a fish can be presented as either freshwater or marine there is conflict in the consumer's minds as to which is the better fish. For future development delineation between fresh and marine species may be the better option with eurhaline species grown in marine sites only. Whether a brand name or otherwise a marketing name adding value by inference seems important. King Reef Barramundi is a clever name conveying a romantic image of a marine reef fish with a royal title for a barramundi grown near a reef in marine water. The data revealed the (competitive) advantage of saltwater fish is more saltwater fish can be sold at a similar price than freshwater fish. The market prefers saltwater because it perceives them as better. The future of barramundi is growing the domestic market by value adding and building an export market to Europe and the United States of America. One respondent stated that the long-term future of Australian aquaculture is export. The catfish data indicated barramundi would be popular there and could be promoted with Australian themes. Two farmers process and value add on site. One is fully vertically integrated with a wide variety of presentation options. The other is limited but is developing a market for smoked barramundi to divert plate-sized fish away from Sydney wholesalers and retailers.

16. Did you have to establish a market or was it already established with either wild harvested or other aquacultured species?

1. Barramundi had an established market and the export market is being established. The product and price are acceptable, but transportation by truck to Brisbane is the weak link and the timings too tight so trying it direct from Darwin.

2. Barramundi's advantage is the market already existed.

3. Not asked

4. Established market for 30 thousand tonnes net import into Australia of low value fish like Nile perch and sea bass. The initial work done for our project established that 1000 tonnes could easily be absorbed in Australia. There more barramundi sold in Australia than is produced and much of it sea bass coming in from Burma and Thailand.

5. Not asked

6. Barramundi has a good name in the market place. It's hard to know what is developing faster the market or the number of farms.

7. The company started with a market for plate sized fish and spent money on advertising plate sized barramundi. Now with over 200 growers in Australia under cutting the market, plate sized barramundi is selling for between $6 and $8/kilo. Fifteen years ago plate barramundi was around $15/kilo but has reduced 60% since. The company has invested $1 million on a processing facility and increased production to support the processing and establish other markets. A time parameter should exist for others to catch up. A small farmer cannot afford or justify a similar facility with HACCP and Aqua standards. This allows proper developmental marketing of value-added product and advertising without others piggy backing.

Summary

Established market

Three (3) respondents said barramundi had an established market, one (1) said it had a good name, two (2) were not asked and one (1) started by establishing a plate market but had to extend his value chain by processing barramundi as the plate market is now limited.

17. How do consumers' perceive your product?

1. Barramundi has a good Australian and international profile. Some prejudice against farmed product, but this is being corrected based on reliable supplies of quality, consistent sized product. The company's fish has been mistaken for wild caught.

2. Market research identified a preference for saltwater fish over freshwater fish which is variable in quality, occasionally muddy and not preferred in Australia or overseas. Started first harvest on 17 Jun 02. The wholesalers want a regular sized fish, consistent quality regularly thereby differentiating marine-farmed barramundi from wild fish on the basis of the wild fish's variable quality and size. Fish are sold whole giving them a three-week shelf life, enabling four day road freight to the eastern states. A seven-day shelf life countdown starts from piercing. Fish is best-processed close market.

3. Developing ISO certification incorporating more thorough house checks and documentation which goes with each batch of sold fingerlings. Their quality and reputation is important, as is a reputation for good quality end product fish. Barramundi production has had problems and industry reliability is still not good enough. The aim is year round constant supply of barramundi, but disease losses and brood stock failure haven't enabled this. Larger fingerlings to the marine farm are 10cm and larvae and smaller fingerlings go to other clients for ~ one cent/millimetre varying with quantity.

4. Consumers do not always know the source of barramundi, but should be confident of those from this company. Volumes are steadily increasing in the domestic market.

5. A good quality, good eating white fleshed fish. Consistency of flavour is a potential problem. Freshwater/saltwater is not the critical issue but can used as a marketing tool. Any pond farm can have inconsistency problems associated with different culture units and different pond conditions. This is overcome by putting the fish through the same process before it goes to market, or like the catfish industry start introducing tasting protocols.

6. Consumers are price dominated and prefer marine barramundi. The company markets its own fish cutting out the middleman to receive a better price. Selling 100 tonnes/year for the last 15 years, price is down from $10/kilo but to shift volume have dropped it to between $9 and $10. Air-freight all fish. People who road-freight may make more. Used to gill and gut but increasingly are doing whole fish anywhere from 1-3 kilos. Don't see plate size as a long-term market.

7. Fresh barramundi fillets have a good market in Australia with promotion, for example in Woolworth's catalogue. Suppliers have to discount during catalogue week, but letting some product out cheap gives people taste and return customers buy it when the price rises. Quality of product is non-negotiable and the company sells fresh and marine water grown fish.

Summary

Customer perception

Data has given mixed signals on consumer perception. Some prejudice against farmed product was corrected based on reliable supplies of quality, consistent sized product resulting in the farmed product being mistaken for wild caught! The stage in perception is a claim that market research has revealed a preference for marine grown fish. The difference between fish grown in either freshwater or marine water appears to be over ridden by the requirement for quality that should narrow the perception gap. The problem is most likely consistency of flavour, further complicated by some with a preference for freshwater fish regarding weedy /muddy flavour as taste. However differentiation between fresh and marine water fish can and will be used as a marketing tool making identity of product source an issue. Companies with production options have the opportunity to develop marine and freshwater barramundi as two different products.

18. Where is your competition and can your market grow?

1. Aquacultured barramundi, wild caught barramundi and wild caught snapper. High beef prices help. The company is the largest provider of saltwater aquacultured barramundi and anticipates competition from marine farmed fish. Price fluctuations don't affect customers and the top domestic restaurant trade could double if consumer loyalty is developed. Growth is moving into other restaurant markets in Melbourne, Adelaide and Perth, then export, then value-added product or the portioned fresh fillet trade. Other markets in Australia are higher volume lower price markets. Barramundi has an elastic demand curve, but the Australian market is limited. Opportunity to exploit international markets pushing the Australian name similar to the Tasmanian salmon farmers. Goal is to be internationally competitive producing similar quality fish at a similar price based on our natural resources. Asian barramundi are not competition in the fresh trade but are in the frozen fillet trade. Farm gate prices for barramundi in Asia is they are similar to Australia. Plate size frozen barramundi from Viet Nam gilled, gutted and scaled is available for $4/kilo. Attempted to sell live barramundi to the restaurant trade early on but have never attempted to ship live barramundi, not a valuable enough product.

2. Freshwater and saltwater aquacultured barramundi. Globally it's all other fish species as well as other meats. Freshwater barramundi will be a second product of choice at a lower price and in less demand which may pull the market down. Freshwater barramundi will compete with saltwater barramundi, because marine farmed fish will set the price, fresh will sell less at a lower price because of customer preference for marine. Wild fish will put a seasonal depression on prices because of supply. Challenge is to find a mixture of markets, exporting more during the winter months of wild fish season, achieving balance between exports and domestics and trying to spread our markets amongst a number of places; Australia, the USA and a few countries in Europe. This is to limit reliance on one place and balance out supplies. Producing a fillet retailed for $19, the company could produce 10,000 tonnes for Australia's market. Producing a fillet retailed for $28, the market will only buy 500 tonnes of fish. The market is in proportion to price. The lower the price, the bigger the market and the lower the company wants to come want to come, the more industrialised it must become. Building a 1000 tonne farm is not industrialisation, but five co-ordinated farms working together each capable of doing 1,000 to 3,000 tonnes is industrialisation. The market might be 1000 tonnes for a premium product, but if the company went to 5,000-10,000 tonnes the fish would have to be sold cheaper than today's prices.

3. The Queensland and South Australian hatcheries. In Australia there is considerable growth potential in the barramundi industry. There may be a future market for fingerling export, particularly if we have ISO certification and disease control, specific pathogen free stock which may not be available elsewhere. In Asia barramundi is not perceived as such a brilliant fish as it is in Australia.

4. The competition might be China in future and the market can grow. The project aim is to establish an industry. Chinese capacity is enormous as their ability to influence markets. Australia has the competitive advantage of good quarantine regulations.

5. Competition is everywhere. Direct competition is other white fleshed fish selling at a similar market price. Competition comes from all sectors, not just seafood.
Fish competitors are bream, snapper and other commonly caught commercial species which are in the same category as barramundi in the retail marketplace, based on price.

6. Aquacultured barramundi. The competition is there because everyone sells individually rather than together. The wholesalers play prices with everyone. The market can grow and the aim is to double production from 200 tonne. The site allows us 500. Saltwater barramundi sell more at a similar price to freshwater barramundi. The market is more receptive therefore stock easier to shift.

7. Imports of barramundi and other species. For example Australia used to get third or fourth grade New Zealand snapper, the best went to Japan. Five years ago when the Japanese economy crashed, high quality New Zealand farmed snapper that used to go to Japan was sent to Australia. Good quality product entering the Australian market cheaply wrecked the barramundi market. Australian farmers beat imported cheap barramundi on quality. Other producers are competition for example the Northern Territory marine operation. They probably have a long-term plan to operate the same in value adding, but down the track. In a period of window the company wants to establish a name for quality for others to catch up. Quality of product is a non-negotiable item. We can sell barramundi grown in fresh water and saltwater.

Summary

Competition and market growth

Competition is everywhere and comes from all sectors not just seafood. Barramundi has an elastic demand curve generating piscine competition from wild caught barramundi, wild caught bream, snapper and other commonly available commercial species in the same retail category as barramundi. Farmed competition comes from beef, farmed New Zealand snapper (occasionally) and aquacultured barramundi, either freshwater or saltwater. Freshwater producers fear increased competition from saltwater fish which will always sell more at a similar price. Farmed barramundi need a mixture of markets exporting more during winter when wild caught species may put a seasonal depression on prices. Market growth depends on developing consumer loyalty and moving into additional markets, export, value adding and portioned fillets. The current fragmented marketing effort needs consolidation. Barramundi can achieve international competitiveness with a clean, green Australian cultural image. As sea bass *Lates calcarifer* is not well regarded in many parts of Asia. The lower the price, the bigger the market. The lower the company wants to set the price, the more industrialised it must become.

19. To what extent does the market drive new aquaculture species development?

1. Market forces drive development in anticipation of profits but the profit period is short lived and must sufficient to cover initial R&D investment. A Taiwanese example showed a set of Cartesian co-ordinates at the initial stage of investment with little or no return. Cracking the technology gives a steep rise to super normal profits, technology is diffused, supply goes up, the curve comes down and flattens the ROI.

2. It doesn't drive development but it should drive the decision points. The market is not interested in telling aquaculture people what they should or should not be growing.

3. Very much, whether it's tuna, rock lobster, the high value fin fish into the South East Asia markets, they are all market driven.

4. The market is everything because of rise in demand and shortage of supply.

5. The market drives demand if the species was, but is no longer available from a diminishing industry, or if a huge potential has identified a species in the market place at a big price. But without critical market knowledge picking a new species is dangerous. The market should be part of the initialisation process and part of the selection criteria.

6. It determines the lot. The amount of demand for new species from barramundi farmers will push how quickly projects go through at the DPI level and the more demand the quicker the uptake of information.

7. Totally.

Summary

Market demand driving new species development

Six respondents said the market drives development. It should be part of the initialisation process and the selection criteria. One said it doesn't drive development but drives decision points.

20. In new species development, how does the developer balance market demand for size, quality and continuity of supply against the realities of production?

1. Early cash flow is usually achieved by selling fish off small, thereby sticking people in a loop. The company grew plate and some escaped attention growing into large fish necessitating selling half as plate and the (big fish) rest in boxes sent to Sydney Fish

Market. The market returned three times as much for big fish grown with less work. The small ones were hand graded live to meet market specifications, then gilled, gutted, scaled delivered to the restaurants and received $14/kilo for the small fish against $9/kilo for the big fish. Profit is in big fish even though extra rations are required. Small farmers are driven by cash flow and survival.

2. It is relative, for example, a company does not have to sell tuna. Tuna sells itself, sometimes all in one month. The same with crayfish, because they are in short supply, but there is no reason why anyone should buy fin fish. Niche product in demand for one month of the year doesn't matter, but competitive product requiring a fight to be in the market every week or month with minimal cyclical variation.

3. Complex question. Some smaller farmers target particular periods of the year, like horticulture. Continuity throughout the year can be achieved but smaller operators would rather hit the peak demand periods. For example some prawn farmers focus on Christmas and Easter markets, rather than try and produce every month, whereas the larger ones like Seafarmers on the East Coast have the continuity.

4. With the luxury of a big company behind the business cash flow is not sought. Fish are around 2.9 kilos, but wanted at 4 kg to give the fillet yields required, hence no concern, but we have to achieve 20 tonnes/week. The entire Tasmanian (salmon) industry would be producing 50 tonnes per week. A well established, diversified business will not be driven by cash flow; it must achieve a positive cash flow, but has time to get it right.

5. It's impossible.

6. This company faces that dilemma. Harvesting one big pen with 30 tonnes of fish and sending it to market is ideal, but that quantity cannot be lumped onto the market. *The market wants whatever size the producer has not got.* If the farmer says he can supply 1-2 kilos the market wants 2-2.5 kilos. The farmer must discover what the market wants and inform the merchants what products he has. The best price means the biggest volumes customers because there is not the continuity of supply. Often with high price the farmer only has a small volume of the size the market is after. Try and hit the peak market times with the biggest quantity.

7. Be market driven through out and start at the end and work it back. The market controls everything. The producer must do what the market wants, when they want and how they want it. If that cannot be achieved don't bother trying. Sometimes requests need evaluating and sometimes farmers must say, "sorry we cannot do that." The farmer either can or cannot do something and there is not a lot of negotiating in between.

Summary

Production meeting market demand

Answers ranged from "it's impossible" to an uncompromising stand of "meet the market or don't even try!" In between these two extremes, one player found a market for large fish by accident, another said fin fish is a commodity and a producer must have a continuous market presence. Some producers can supply all year round (prawn and re-circulation farmers), but others producing a seasonal species can supply only for restricted periods. Cash flow and survival drive small farmers but a large established diversified company has the luxury of being able to properly develop the species or product. An insightful response referred to the equation as a dilemma warning that quantity cannot be lumped onto the market which will want whatever size the producer has not got. Here the farmer must meet the market by forewarning and negotiating with the merchants on his product status and if possible hit the peak market with the biggest quantity.

21. How should the aquaculture industry innovate?

1. At two levels with individual entrepreneurs innovating, people joining and supporting their producer organisations and talking with other members to identify key strategic objectives. Then engaging the funding agencies and being prepared to make contributions to get focus on issues and work cohesively together to achieve outcomes. For example genetic improvement programmes may benefit people running the nurseries and hatcheries. But the bottom line is, if the industry does not lift its game it will be out gunned by those organisations doing this progressive work.

2. Look at each specific sector and identify the requirements. An MBA in Aquaculture or a degree in Aquaculture Engineering and more mentoring of leaders as they come through and attracting good people to the industry would drive other things.

3. Stop reinventing the wheel. Insight and improvements are gained by observing doings in other countries. Two staff went to Europe to observe hatcheries and nurseries and learn; reported back and re-engineered the centre and improved health planning. Be current with the latest global technology. Develop international networks, work with global companies which have access to information from Norway, Spain and Chile. Several governments are supporting Australian aquaculture with a solid R&D platform.

4. With good people, confidence and experience, knowledge transfer, and performance indicators to target the issues. For example escaped fish is a huge performance indicator, which must be reduced to zero.

5. Mechanisation, product innovation development, varying the product like value adding to increase market share and cut out the wholesale chain by going direct into retail with a value added product. This is up scaling because of pressure on farm gate prices. Australia needs to develop more innovation for specific industries here.

6. Ideas get taken up on the basis of what is the best for each company. Our best advances have come from staff innovations. Quite often the quickest way to advance is to see what others are doing in Australia and overseas, just distribution of knowledge.

7. Technology is the only way to achieve low production costs enabling future competitive performance. Fifteen years ago the company sold fish for $15/kilo and was losing money now it sells for $8/kilo and makes money.

Summary

Innovation in aquaculture

The main three areas of innovation identified were education, technology and knowledge transfer. Australian aquaculture lacks business aquaculturalists and aquaculture engineers. The presence of these two professional streams would enhance technology upgrades, innovations and knowledge transfer in the areas of re-engineering, value chain streamlining, staff development, representative associations and adoption of overseas and inter species technology.

New product processes

22. Do you have a formal process for new product development?

1. No

2. No

3. No

4. Yes

5. No

6. No formal process that has to meet certain criteria, but a partial process in the construction of a report highlighting attributes of various species for presentation to the

Board of Directors. Precursor to a desk top review. Development of a new species requires domesticated broodstock to produce larvae and can take two years from first larvae to including it on a DPI license. In this process highlight species potential for the license, look at obtaining some broodstock and gather the information during the process.

7. No

Summary

Formal process for new product development

No (6), Yes (1).

The yes respondent was part of a larger organisation which he thought had a formal NPD process at its headquarters. One no respondent said his company did not have formal process to meet certain criteria, but a partial process in the construction of a report highlighting attributes of various new species as a precursor to a desk top review.

23. How should the developer of new aquaculture products involve future potential customers in NPD?

1. By networking and establishing interest with the marketers and research community as done with the mud mussel (mangrove cockle) programme. Technology outward and marketing inwards.

2. Involve them at the assessment stage and ask about the product's suitability, fit, what's special about it, what price can it achieve and what volume the market will take. Do it in a way that doesn't lead people to give a "wanted" answer. That can be difficult because often they will give an encouraging answer, whereas the truth is required. "Yes this fish is nice but it's only worth this much." A document stating how many tonnes of various species are sold at what price may help aquaculture in Australia. That with some value chain information would knock out some potential species at the beginning. Predicted price rarely equals market price.

3. Involve them before starting. Begin with the market and talk to everyone in Australia and overseas outlining the plan to give and gain a feel for its potential.

4. Most species being screened would have a customer base somewhere in the world. For example, barramundi cod is a prime species in the Asian market. But outside that market it is barely known. It's a live fish market but limited even though the Chinese market is huge and won't sell it in the USA or Australia without huge work. These are not easy fish to farm, but the knowledge already exists in Hong Kong or that region.

5. Very important to involve them in market feed back or consumer feed back and critical in the initial selection. The marketing side may also be interested in developing the product too so there may be some sort of co-operative benefit.

6. Customers must be involved, particularly with hatchery. The hatchery (fingerling) market is only available if people are set up to take the product we are selling. The turning point came with this set up around 5-6 years ago when the industry was big enough to justify a hatchery on a commercial basis. Before hatcheries were built to supply stock to a growout farm. It didn't matter whether they made money or not. Now this hatchery must work as an individual entity and up until five years ago it couldn't because the market wasn't there. The company farm gets 20% and the rest goes to other growers. We're only producing 50%-70%. The other growers cannot be looked at as competition if the hatchery is to succeed. The hatchery can only make a profit if it is selling as much product as possible. The Directors look at the hatchery and farm as an entity together, but the hatchery is separate. This gives a realistic idea on pricing. The hatchery has the highest price for larvae, but is the biggest supplier. The hatchery has the highest prices in fingerlings and tries and not come down in price too much because it then subsidises another farm. The hatchery doesn't get much feedback on fingerling survival rates because farmer customers don't want to look bad. If they have a complete failure they try and keep it quite and no information is asked for. There is 50% fingerling survival rate in the company's farm operation, but these survival rates have to take into account escapees, which is probably greater than mortality. The pond growers have escapees they still retain the fish in the ponds, therefore should achieve higher survivals. Larger sized fingerlings=higher survivals.

7. Involve future customers but not too far until the new product development looks like it can be achieved.

Summary

Customer involvement in the new product development process

All respondents except one would involve customers at the assessment stage. The one out wanted to wait until the product looked as it could be achieved.

Customers in Australia and overseas should have the plan outlined to so the developer may gain a feel for its potential. Questions for customers are product suitability, fit, what's special about it, what price can it achieve and what volume the market will take?

Predicted price rarely equals market price so a regularly updated paper detailing fish volumes, prices, chain players and value adding would provide the information to eliminate some potential species at the start without surveying customers. Most species have a customer base somewhere world in the world to assist in an initial screening.

24. When should representatives from all company functions (research and development, production and marketing) become involved in the NPD process?

1. From the outset because there may be opportunities or flaws that won't be recognised from a narrow perspective. As the focus shifts, set goals or targets in different areas. Every action must be under pinned by the technical capability to do it. Regulatory implications are likely. Opportunities may exist for funding or assistance and information through networking with other producers and develop markets. It's parallel processing Linear processing is too slow and ineffective.

2. At the project plan stage outlining the project to start and requesting input for feasibility assessment.

3. Right at the very beginning.

4. Early. Get people's views on a new product before formally announcing as a focus for the company.

5. From the start.

6. At the start. The fingerling producer must promote the end product, therefore everyone needs to participate to achieve proven production of stock, then the industry has to work through all the hurdles quickly, some of which are unseen. For example every species has different disease problems which are easier overcome by wide participation than one pioneer company alone.

7. R&D facilitators are too focussed on their own pet projects.

Summary

Cross-functional representation in the NPD process

At the beginning (5), Early (1).

Respondents saw the need for early involvement with one commenting that R&D facilitators are too focussed on their own pet projects. This was a general comment throughout the survey and reflects the need for business input. This process is part of the desk top review and each step in the process must be under written by the technical ability to execute the task.

25. How important is the new aquaculture product launch into the marketplace?

1. Very important, but differentiate between the actual introduction and testing of the products and advertising them. Delay advertising until the product is proven.

2. Not important, except for a niche species. Finfish are almost a basic commodity to be bought regularly by consumers. Marketing is not important because the fish isn't positioned high. If a firm is producing thousands of tonnes, it is the quality of the product which is crucial and the distribution chain will probably do a lot of the marketing. Branding is important, but may only be important to the wholesaler the retailer may never see it. Wholesalers are likely to identify salmon for example as Tasmanian rather than from a specific company. The intermediate wholesaler does not want to identify his source to the consumer. Companies can challenge long term brands by selling fish in a new box with a new label and same price with no value added. If the wholesaler is offered fish and he judges the quality to be equivalent for 20 cents less then if branded, the brand wasn't worth 20 cents. Competing as small individuals in a global market is hopeless the costs are too high.

3. Important for branding and maximising investment when a new product enters an undeveloped market. Not important if the product is already on the market.

4. Important, but the product has to be right.

5. Critical, probably one of the most important parts of the process. But it can be slow and unless there is a lot of money allocated to lifting the profile of a new species. That money does not even exist in a new industry.

6. Critical-make or break. Prices go down rather than up and whatever price is set initially could have a long-term effect on the industry. The launch must be done correctly and backed by quality product in sustainable supply. Bad reports in the initial stages can ruin a product's reputation necessitating renaming and re-launching the product.

7. Not important. Pilot selected niche markets with unannounced product and let the market inform of problems and hurdles ahead. Then do a re-assessment so that when the product is being promoted the majority of hurdles or overcome and knowledge is acquired to deal with problems as they occur.

Summary

Product launch

Critical (2), Important (2), Very important (1), Not important (2).

The affirmative answers cautioned against releasing an unproven product. Differentiate between introduction, testing and advertising, by piloting selected markets with unannounced product and monitor market feedback to build a data base of problems and obstacles. Re-assess the information to handle these when the product is being advertised and promoted. The launch is not important if the product is already on the market (as so many wild caught species are), but a good launch is important for branding or maximising investment. One "not important" respondent also said branding is important, but brands are not safe. The effectiveness of brands may be diluted if they are generic for example, Tasmanian salmon. A brand can be readily overthrown by cheaper product.

26. How does new species development feature in the future of aquaculture?

1. Important for the next 20-50 years, then flattening out. A great period of innovation and learning, requiring integration of species and systems and market development. Big developments will be revolutionary like farming cephalopods and species with very high growth potential. Control of R&D funding decisions *must be based on business case analysis and the role of professional researchers balanced by people involved in both farming and business analysis.*

2. Important. The big push overseas is cod farming. Players want a white fish on the global market. Cod has been chosen because it can be farmed in all existing salmon farming areas. Turbot and halibut are specialities. Global concentration of effort, R&D funds will go to cod which has the same technology as salmon.

3. Important and ongoing. Though many species are suitable for development in NT, R&D expense will preclude most of them because they are all difficult to develop. The FRDC as a research-funding organisation wants to improve existing species rather than work on new ones, but if market demand is strong, development will happen irrelevant of support from funding organisations.

4. Important to meet the forecasts of wild fish catch rates going down and tropical aquaculture poses the best opportunities:

5. Critical and part of the natural progression for industry to *stay in front and investigate potential new species because if not the industry may be left behind.* The farmer is in a better position investigate new species if the current species under culture is successful and the existing infrastructure can be used for potentially more valuable species or to grow a new species in polyculture.

6. Very important. Probably the biggest industries are yet to come. Every species is known but not for aquaculture. *Maybe the best one hasn't been found or highlighted.* With advances in technology a bad trait in a potential new species can be overcome and suddenly it is no longer a limitation. For example a species may suffer from bad gill flukes and a technique is developed to make it a non-issue.

7. Important. Some of the species we are thinking about now will be grown by the next generation of fish farmers. For example the groupers.

Summary

New species development and the future of aquaculture

Important (5), Critical (1), Very important (1).

Control of R&D funding decisions must be based on business case analysis and the role of professional researchers balanced by people involved in both farming and business analysis. The data indicated if demand is strong, development will proceed regardless of support from funding organisations. New species development is ongoing for several decades developing the species under desk top review now. During this period, species currently not known or highlighted may emerge, building even bigger industries than those of this decade may. For example several respondents in general conversation identified silver cobbler *(Arius midgleyi* Kailola and Pierce 1988), a freshwater fish, as a potential new aquaculture species. Also known as shovel-nosed catfish, silver cobbler occurs in Northern Australia and southern New Guinea. Cobbler has been observed shoaling around cages in Lake Argyle and is well received in the Perth fish markets. Research and development costs preclude many potential species from commercialisation, as do current deficiencies that could be overcome by future technology. Investigation of new species is assisted if the current species under culture is successful and existing infrastructure usable or the potential species is adaptable for polyculture. For example, the next big global finfish species Atlantic cod *(Gadus morhua*

Linnaeus 1758) was chosen because it is a white fleshed marine fish has the same technology as salmon and is adaptable to all existing salmon areas.

New product development agribusiness value chain

27. Why is barramundi aquaculture successful in Australia?

1. Barramundi is tough, fast growing and farmable. The production technology was available from Asia. It's fairly boneless with a good tasting flesh, has good market acceptance and is versatile with uses for the wind bag, head, belly flaps and smoked.

2. Success is yet to be proven, but it's easy to produce juveniles, an easy fish to farm and well recognised by Australian consumers more for its name than taste, real or perceived. Suited to Northern Territory which has the correct temperature profile and the Australian flavour image can be built on.

3. It is yet to be proven. Volume is small by international standards and the next 5-10 years will determine whether it can become a significant international industry sector. To survive barramundi must become an internationally marketed species.

4. The name barramundi is well known in Australian and overseas, but the species is yet to be proven in aquaculture. Freshwater barramundi may have problems as people prefer marine fish. Until barramundi mariculture the industry was re-circulation and pond aquaculture. Barramundi is sea bass in Asia is not highly regarded.

5. The name barramundi. Had the market and name not been established the industry would have struggled, like other new species for example, jade perch. Suitability for aquaculture. Breeding technology was available from overseas, euryhaline, environmentally tolerant, accepts pelleted feed and grows fast. An equilibrium has been reached in marketing and promoting the product. Market expansion happens slowly and painfully and is happening by increased production and lower prices. The fish expands slowly into other markets because it's cheaper than something else is. The industry is not creating demand for barramundi because of a lack of resources. $25,000 is allocated for promotional activity this year but it should be $250,000 to create a growth in demand.

6. Barramundi's name and ease of production gives it "8 out of 10 stars."
Quick growth rate, artificial diet, euryhaline, grows to whatever size is required. Hatchery is relatively easy. The food cost is probably quite high, a very large component of production cost. Lack of stars in certain areas can be "managed around." For example they are cannibalistic a bad trait overcome by efficient grading.

7. Barramundi's name as a premium Australian seafood fish and the technology to produce it was available from overseas and market acceptance in Australia. Knowledge of breeding, production, nutrition, diseases is documented including disease cure rates. The name is vital for example the code name for the new model Ford Falcon is The Barra. In Cairns the Balaclava restaurant has a Barra bar. Cinzano made a seafood wine, red and white for export. Ken Done did the labels, it was called a Barramundi Wine a premium seafood wine. Because of cash needs during development the fish has sometimes not been up to standard. But because of its name the market forgave these deficiencies. *Another new species would not have that tolerance.*

Summary

Barramundi's success

Three respondents said barramundi's success is yet to be proven, whether it's produced in fresh water or marine water. Collectively, all seven respondents identified the following attributes, which have made or may make barramundi aquaculture successful in Australia:

1. Well established name with Australian consumers (5).
2. Available technology for start up from overseas (3).
3. Easy to produce juveniles (2).
4. Tough, fast growing, environmentally tolerant adaptable to aquaculture (3).
5. Euryhaline (2).
6. Accepts artificial diet (2)
4. Acceptable to the market; good taste, boneless, white fleshed and versatile.

Barramundi's name and ease of production gives it 8 out of 10 stars and had the market and name not already been established the industry would have struggled. Because of financial needs during development the fish has sometimes not been up to standard. Because of its name the market forgave these deficiencies. Another new species would have that market tolerance. Consumers' prefer marine raised fish which is a problem for freshwater raised barramundi. In spite of all these fine characteristics, barramundi needs promoting to increase consumption and to become an internationally marketed species.

28. Was a new product development process applied to barramundi?

1. Don't know, but market development is now needed.

2. Yes, for this company. Two or three feasibility plans elicited internal and external comment which wasn't always expert. The process lacked rigour and a more rigorous process would have been beneficial.

3. Yes. The Government as a good idea for Northern Australia and the technology was transferred here from Thailand but the process lacked depth of analysis

4. Yes.

5. Yes, but lacking rigour.

6. Yes. The two original companies here did correct research and the right things. This company went too big too quick, the pilot scale was good, but when full on weren't able to get the income to support the operation. Staff has gone from 30 to 4 and the 4 produce more than 30 did. The 30 may have worked harder than now, but the 4 have the advantage of the knowledge and experience. A recent publicly listed company which failed had a good idea but the execution was poor, lacking a proper process. They were probably three years early, but you don't spend $20 million on a good idea which isn't proven. Start with a garage and a tub to investigate fingerlings then build a few ponds.

7. No. This company did many things wrong and ran at a loss for 7 years before making a profit. New growers are still doing a lot wrong but product has been forgiving enough to do it.

Barramundi

New product development applied to barramundi

Yes (4), No (1), Don't know (1).

The "no" respondent was cited by a "yes" respondent as having used a new product development process for barramundi! Again the point was made about barramundi's name (and possibly physiological characteristics) being instrumental in forgiving errors in its development. General comment for the yes respondents was that the process lacked rigour and depth of analysis

29. The value chain is a series of stages or events from selecting a species for culture, to marketing that species: What are the critical components of the barramundi value chain and how are these linked?

1. The planning started in 1992, the company was established in 1993 and earth works and stocking began in 1993. The initial production system concept was introduced on a steep learning curve. The next stage is to diversify. The farm is on a flat flood plain next to the river using tidal exchange. The ponds are connected hydraulically to the river using valves and channels to exchange water. Controlling the water and fish is vital. There are difficulties managing the tides so now water is pumped into the ponds catfish style which is easier to manage and carries more fish. The farm is evolving with introduced procedures, HACCP plans, food safety courses and OH&S and developed systems for tracking data and maintaining books. Fish are sold before harvest, chilled rapidly to zero with ice, packed and dispatched aiming for the freshest possible product with the maximum shelf life. The fish have been mistaken for wild caught.

2. Hatchery comes first and was established with a research facility 4-5 years ago. The company contracted and under wrote to extend the hatchery for barramundi fingerling production and contracted them to supply fingerlings for 4 years.
The company is two years into that and will roll it into a new contract or we have the option to buy that part of the facility. Fingerlings cost us between 60-80 cents depending on size. They measure from 60mm to 120mm. 120,000 fingerlings deployed in July and enclosed in pens 9 m deep with eventual stocking densities of 50 kilograms/ cubic metre.

Cage segregation goes from fingerlings>10grams>300g>1.2kg>1.6kg>2.8kg. Cage mesh in this environment currently lasts for 9 months and is lifted one metre twice to compensate for rust at the water line. Happy to get 12 months out of the mesh, very happy for 15 months and delighted to get 18 months of life. The mesh is anode protected against electrolysis and the anodes sacrificed. Cage infrastructure should last 10 years but only lasts five years, which is a problem to be solved. Australia lacks aquaculture engineers. In UK aquaculture engineering firms design complete aquaculture systems. We don't have a good system for the tropics yet.

The best industrial fish farms produce and box fish @ $4/kilo, worst are $8/kilo, average is $6 kilo. Assume a new fish can be cultivated at 20 kilo per cubic metre and it has a growth cycle of 12 months. Work out its fillet yield and analyse the chain. The profit margin throughout the chain dictates cost to bring the fish to a retail market. *Is that a better price than another fish can be brought to the retail market?*

The new fish initially earns a premium but with increased production will drop from the new category into the next that people buy for quality, then becoming more common will drop again a lower general category which people buy on price. Tuna is an

ideal aquaculture species with limited production and a niche market generating a 30% net margin, whereas most aquaculture species are working on a 10% net margin. A 10% net margin in a farming operation is hard to maintain profitability, because there are problems from year to year and a 10% net margin can be reversed to a 20% loss.
World base costing data exists for sea production at X amount, pond production at Y amount and recirculation at Z amount. In 20-30 years species adaptability to recirculation systems will govern its ability to be farmed.

The critical component is cost of production, necessitating an efficient and simplistic system and inbound and outbound logistics. If these are done correctly quality fish can be positioned in a market where supply exceeds demand. Target price is $8.50 on the East Coast and sustainable for small volumes. Second target is lowering the price to $7/kilo to expand the industry to 3,000 tonnes. The company has been selling fish for three weeks at 3 kilos but would prefer to sell at 4 kilos thereby retrieving more fish over 2.5 kilos. Barramundi's long shelf life enables a range of options; road freight instead of air-freight and a longer time frame for people in the chain and the end points have to sell the fish

The fish are fed at 1500hrs each day with Skretting fish feed comprised of:

Fish meal	40%
Fish oil	20%
Wheat	12%
Vegetable protein	28%

This preparation is milled in Tasmania by company mills and sold the farm for between $1500 and $1600 per tonne which is the same price as for an external customer.
The company is re investing in its value chain by expanding fish production to grow the fish feed business and working on feed development for tuna focussing on pellet feed, proving pellets work, proving pellets are commercially viable, converting the market, then working out a formula for using less fish meal (pilchards) and fish oil in tuna feed.

The company trialing peroxide to combat gill fluke, a 2-mm organism that sucks blood by attaching itself to fish gills. The other disease problem is bacterial bloat caused by a vibrio photo bacteria that started in the hatchery and infects fish up to 1.5 kilos.

No plans for expansion until the current operation is perfected, then it will move as one fish, as one feed and as one market with a mix of individually owned farms, share farms and company farms. The future is developing owner-operator farm units and providing support logistics and rewarding the farmer according to his risk and capital employed. The company does pigs, poultry with suppliers and contractors and it's own farms, in fish the company owns most of the farms. Big companies will consolidate aquaculture, buying up players, rationalising logistics and marketing, then de-consolidating operations focussing on individual farms by leasing out, contracting or share farming depending on the investors mind frame and capabilities. One big agribusiness network operates the logistics and marketing but the individual farmer has control over the profitability and future of the farm.

3. Broodstock management, hatchery production, fingerlings, growout, then processing, packaging, value adding, freight and the marketing mix. The reliability of fingerling supply needs improving. The husbandry of barramundi is basic with no domestication of stock, using wild stock with little use of second generation broodstock. No breeding programme yet with 15% improvement between generations there is significant room for improvement. The hatchery has had viral bacterial problems and disease control is vital, control aims for specific pathogen free stock.

Sea cages are good for growout using marine mesh rather than ordinary cages in NT and a level of automation is needed; the aim with all the large industrial fish cages is to increase tonnes/man/year, thereby reducing production costs. For example the Tasmanian salmon industry is behind the Norwegians. Long-term competition will be other protein sources like salmon, getting lower in cost with more people consuming it.

4. The chain immediately from the market back to the farm is the cold chain. Unless that is correctly done at the right cost it's going to break the farm. The cost of production has to mean profit. Potential problems are escaped fish and disease.

5. There are three people between the farm and the consumer and they all want a percentage hence a low farm gate price. But that equates to what is being sold, a whole chilled fish. The product is limited in that form outside the wholesale market. Its form must be changed in order to cut out the wholesalers and go further down the chain. That requires processing or value adding. There are some areas lacking for example, commercial processing. The wholesalers are doing all the processing now as part of their costs when they on sell. There is not much processing done on site and few farmers have processing rooms. The only other production of processed fish direct into consumer retail is through a local vertically integrated farm straight into the supermarket chain to try and cut out the wholesalers by doing all the processing. Based their figures must do that to stay viable with the investment he has made, a huge processing facility. Originally the whole chilled fish were to go through a processor and then to Woolworths but the figures didn't add up. So the processor was eliminated from the chain and the company does not require the same margin as the wholesaler. The industry is producer-wholesaler, with some producer-retailer in the restaurant trade.

6. The hatchery functions as an individual profit unit in the company's value chain. There are two of the chain units here, larvae, a separate entity and fingerlings. Cheap larvae enables more hatcheries, lower fingerling price and farmer benefit.

DPI has stepped out to let the industry try and survive by itself. Without larvae or fingerling supply it will fail. DPI has said if that happens they will step back in. The turning point only came with this set up around 5-6 years ago when the industry was big enough to justify a hatchery on a commercial basis. Before hatcheries were built to supply stock to a growout farm. It didn't matter whether they made money or not. Now hatcheries must work as an individual entity and up until five years ago it couldn't because the market wasn't there. The hatchery supplies about 20% to our farm and the rest goes to other growers. Other growers cannot be seen as competition if the hatchery is to succeed. It can only make a profit by selling as much product as possible. The hatchery has the highest prices in fingerlings and tries not come down in price too much because it then subsidises another farm. The farm has about a 50% fingerling survival rate, but those survival rates have to take into account escapees which is probably greater than mortality. Pond growers have escapees they still retain the fish in the ponds and should achieve higher survivals. Buying larger sized fingerlings=higher survival rates.

Grow out seems secure and the only other problem is having too much end product and nowhere for it to go. There is a need for value adding that hasn't been explored at great length. Salmon is way ahead of barramundi which within two years will go the same value adding way as salmon. Farmers sell whole plate fish which has little value adding opportunity other than fillets. Airline contracts are an option. A local farmer does spring rolls. The conversion of a fillet of barramundi to a spring roll means $9 for 12 spring rolls which have about 200 grams of meat. The multiplier factor of their product means the farm need not be large to produce a big profit. Smoked barramundi is fine. It tastes nice and is slightly off white in colour. Barramundi may have potential in higher value product lines like sashimi.

The hatchery sells 30 (0.4g), 35 and 40 mm (1g). We have two price structures, under 10,000 and over 10,000. Over 10,000=1 cent/per mm, with packaging, freight and GST on top. Under 10,000, a minimum order of 1,000 @ 1.1 cent/mm. We are operating at about 50%-70% of capacity. Company production is limited by the number of orders received. Best run to date is around 900,000 fingerlings. Survival was above normal and were stocked fairly heavily. The hatchery can do 500,000 comfortably.

7. Barramundi is a very tough fish. It's a strong product *with probably one of the longest shelf lives of any fish.* The company did trials on barramundi on ice for three weeks then filleted and was still quite edible fish. It's a good white fleshed fish with a unique flavour. Broodstock is 3rd generation and can breed at any time on demand. Spawning them is by either an hormonal implant or an injection. They spawn 36 hours later. Larval production-barramundi produce 250,000 eggs per kilo body weight of the female. The average female is 10 kilos plus. Running 3-4 females, there's 3 million eggs per litre so over 15 million eggs. The larvae turn into fingerlings and 21 days later they are usually 25-30 mm long. Runs are over 1 million fingerlings and 4-5 million fingerlings are done per year. They are counted them at every stage to keep control of stock. The nursery is all 10 tonne tanks, re-circulating and 100% exchange per hour and 100% total water exchange every 24 hours and stocked at high densities. All the tanks are oxygen enriched and have ozone hooked up. Its all climate controlled. The farm at Liverpool Creek consists of 20 small nursery ponds in which are kept overflow fish from the hatchery. The fish are kept in cages whilst being graded with a roller grader, then on grown them to about 150 mm which is stocking size in the grow out cages. The grow-out cages and grow out ponds are all 10x5 metres. The fish are transported to Mourilyan in 7 tonne tanks then placed directly into the cages or grown in the smaller ponds. The cages are stocked with 6-8 thousand fish usually 150 mm long. The cages have lids so the birds cannot get them. Cages are stocked close to the outlet and water flows through them pushed by the paddle wheels. The pond is set up with a series of cages. Every pond on the farm is stocked at a different level and age so there is a rotational harvest system. 10x5 cages are 2 metres deep. The fish are happy with stocking densities of 4 tonne/cage and have gone as high as 7 tonne. They are grown in cages until nearly plate size to avoid bird predation, then released loose into the pond and manually fed in one part of the pond. The paddle wheel faces into the pond and the food thrown into the paddle wheel and dispersed. Some ponds have up to 70 tonnes of fish in them and sometimes we will feed a whole pallet of food to one pond. Everything is set up with back up power supply with five generators around the farm ranging from 100 kva up to 250 kva each. The new processing facility does the whole fish pack out, our filleting, value adding and modified atmosphere packaging. It makes up to 6 tonne of ice per day and targets a 2 kilo fish, beyond 2 kilos the barramundi fillet gets too thick. It's different from the salmon which has a long fillet, the barramundi fillet is nearly as wide as it is long. More than about 3 portions off a fillet make the portions only about 1.5 inches long but are about 5-6 inches wide, oblong shape and they don't look nice in a pack. Portions are weighed by a set weight portion machine, the fillets are translucent, the clearer the fillet the better the quality. The fillets are all pin boned and the portions check weighed. Anything under weight all goes to New South Wales. Two kilos of portions per tray and the trays are put through modified atmosphere packaging machine, which can do 6xtrays/minute which is around 12 kilos, sealed, gassed, labelled and ready for the supermarket. Some days the whole six tonnes of ice the ice room can produce are used. Trays are packed two per box with ice packed around them about a kilo, then labelled and sealed ready for dispatch.

The company can do a lot more with its existing product in cost of production allowing cheaper production enabling a bigger market spread. Barramundi's carcass doesn't have the same amount of uses as salmon it can be developed. The company has just completed a major expansion; building new processing facilities to value add barramundi and develop new markets for existing products, currently harvesting 20 tonne of fish per week all year round, producing in excess of 1000 tonnes per year. Having spent $4,500,000 on expansion a plateau of stabilisation has to follow.

Summary

Critical components and linkages in the agribusiness value chain

Before embarking on a new species a virtual chain should be configured to assess farm gate price. Barramundi's technology was available from overseas for uptake, therefore respondents skipped idea generation which initiates the chain and began participation at the stage of site selection and development. Because the euryhaline barramundi has so many site options, the sites visited varied from those fed by freshwater, to brackish water sites fed in part by tidal exchange and marine sea cage sites.

The next critical component was availability of brood stock. One vertically integrated company had third generation brood stock, suitable for classification as *domesticated barramundi* and one hatchery had no domesticated brood stock, but relied on wild caught fish for brood stock. Third generation brood stock enables significant genetic improvement between generations.

Hatchery establishment and operation is a critical component and ease of fingerling production a key selection criterion. Fingerling acquisition was by contract, commercial sale and vertical integration. Sizes ranged from 30mm (0.4g)>35 and 40 mm (1g)>60mm to120mm and cost between 60-80 cents per fingerling for the range 60-120mm which are sold under contract to under 10,000 with minimum order of 1,000 @ 1.1 cent/mm to over 10,000=1 cent/per mm (with packaging, freight and GST on top) from a private hatchery which has the capacity to produce 500,000 comfortably.
The hatchery has a survival rate 50% on its own sea cage farm. This figure includes escapees a problem pond farmers do not have, though buying larger fingerlings enables higher survival rates.

Cage segregation goes from fingerlings>10grams>300g>1.2kg>1.6kg>2.8kg.

One company had begun conceptualising value nets by thinking about organising production units (individual fish farms) under a variety of management options; company farms, individually owned farms, leased farms and farms under contract to supply the firm with fish. Feed is another critical component. One company produces its own feed and sells to the farm at regular commercial rates

Respondents identified the cold chain as the critical linkage from the market immediately back to the farm operating in several ways using road, air and sea freight and in all cases enhanced by barramundi's long shelf life of three weeks.
Though one respondent in a previous question identified long distance road transport as a weak link. Operators have their markets organised and segmented, often selling the fish before harvesting, then harvesting, chilling rapidly to zero with ice, packing and dispatching to retain maximum freshness and shelf life.

Respondents saw being euryhaline as a bonus rather than a selection criterion, but a recurring theme throughout the survey was anxiety about the difference in taste between marine and freshwater barramundi. For this there are few answers other than to further explore taste preferences and value adding, an area with unlimited potential for new product development rather than new species development. Though respondents are investigating new species, several thought there is more to be done with the existing species, barramundi. The domestic market is limited unless the barramundi industry broadens its offering. This next step into differentiation and value adding is possibly the most critical component of the chain.

30. Could another species achieve barramundi's success?

1. Yes, but not easily in the domestic market and at the expense of something else. States without barramundi or salmon are probably looking for new or alternate species. New species development is currently driven by State interests. Barramundi farmers need to liase on R&D priorities with prawn farmers other pond farmers. Too much is driven by State's interests. For example the $8 million reef fish facility in Cairns. Established farmers needs relate to production systems and technology.

By all means establish a super reef fish research facility in the right place in far north Queensland but make money available to farmers who have invested much, generating import replacement product and now export.

2. Yes, depending on the market, which is a boneless piece of fillet in Australia but other markets have different requirements. It reduces to quality and price.

3. Don't know. Barramundi is in an early stage of industry development and not yet a proven success and technology will change it. Many varied products for varied markets with varied production systems including new prawn and finfish species, micro algae and sponges from which to extract chemicals are under investigation in NT, the production costs of which are so different that some of them may find it difficult to make money.

4. Yes, but not as quickly.

5. Yes

6. Yes

7. Yes

Summary

Another species achieving barramundi's success

Yes (6), Don't know (1).

Three of the yes answers were qualified by not as easily, nor as quickly and depending on the market.

31. How important are strategic alliances in new product development?

1. Extremely important and should be as broadly as possible.

2. Strategic alliances in production systems, distribution systems and selling and marketing systems are critically important to speed up rate of return if profitability is not destroyed by paying too dearly for them. They enable use of existing infrastructure and people with existing systems in place and using the existing aquaculture chain to cut costs of production, distribution and marketing/selling. They enable trading off money for risk by entering into alliances to spread risk by allowing others to farm with the option to continue after commercialisation or be bought out at agreed multiples of profit. Globally it will the chicken model whereby big corporate companies will control inputs and marketing and allow individual farmers to control the farm units to take a lot of the working capital out of the business.

3. Very important to collaborate with other organisations on new species R&D to minimise risks and costs in the development of new products. Without an industry player funding agency money is difficult to obtain.

4. Very important, particularly marketing.

5. Critical particularly between the new product developers, the marketers, support services and feed mills.

6. Co-operative joint ventures are good, but may hinder the rest of the industry. One hatchery is saying "we have set up this hatchery we have to try and justify it as a private business." They will sell fingerlings and larvae to whoever wants them after they supply their strategic partner. They are supplying at a higher price than industry, but it was a lesser price than this hatchery, but they no longer affect this hatchery's sales. It is hard involving a government department and trying to be impartial at the same time, providing a service to the whole industry, not just those directly in contact.

7. Only important for the production cycle not for the marketing. If marketing a new product it must be marketed as a different product. Marketing it as a similar product will denigrate the product.

Summary

Importance of strategic alliances

Very important (3), Critical (2), Hindrance (1), Only important for production not marketing (1).

Strategic alliances enable the use of the existing aquaculture chain with its infrastructure, systems and people to cut costs of production, distribution and exchange. They should therefore be economical to operate otherwise their value may be negated. Entering into alliances with operators of farm units to take working capital out of the company spreads risk. These alliances may continue after commercialisation or be bought out at agreed multiples of profit.

32. How big are the issues of site availability, water value and use for new species development?

1. Very important irrespective of species. The opportunity for new species development is greatest in a site unsuitable for existing species. New species should not compete for sites with existing species.

2. Site availability is absolutely critical for finfish because there are only about six sites left for finfish production using sea cages in Australia and the species must be suitable to the site. The same applies in freshwater as Australian resources are limited. With cost-effective re-circulation systems site availability would be irrelevant as they can go next to the market growing any species. (10-20 years time). Competition is great and the ideal site is one no one else wants with shelter and good current movement. Sydney Harbour is ideal to farm finfish, if there was no competition because it is right next to the market. At this site there is a two metre swell roll, but outside the inlet it will be a seven metre swell. Biggest movement here is in February with 3 knot currents and a 7 metre tide. Darwin has 7 too. The tides go through a two weekly cycle. The peak tide is 8.2 metres and the lowest is point 3 metres. February is the worst time of year.

3. Critical. Throughout the country there are different factors. The Great Barrier Reef prohibits cage development and the cost of land on the East Coast is high compared the NT. Aboriginal aquaculture has big advantages because Aboriginal land ownership is long term and unlike terrestrial farming cannot be sold off when real estate rates rise.

4. Very important to get the site right. Cage and securing technology handles 3 knot tides which is fastest in February at peak spring.

5. Critical in aquaculture in general and for new species, but often new species can be farmed within existing infrastructure.

6. Huge. The reef fish industry cannot progress in Queensland because no sites are available for coral trout and barramundi cod which need good quality water. Developers of coral trout will need re-circulation systems and most of them haven't got access to saltwater. The other alternative is prawn farms, but the water quality may not be adequate. Because the unavailability of sites inhibits the production of some species new species suitability to available sites is an important selection criterion.

7. Paramount. The facility was built for the tonnage production planned years ago. Allowance was not made for the growing extraction rate from the river is probably running at about 20% of its capacity 15-16 years ago. This is because agriculture has changed from broad acre non-irrigated crops to intensive irrigated horticulture crops. The Liverpool Creek has an adequate farm size and adequate water supply for the level of production. Beyond current maximum water consumption water quality becomes an issue unless the farm can re-circulate.

Summary

Site availability, water value and use

Sites are far more important than is generally understood, backed by the responses of very important, huge, critical, absolutely critical and paramount. Throughout all the interviews a "chicken or egg" rationale emerged; what comes first? New species or new site? The ideal site is one nobody else wants and the opportunity for new species development greatest in a site unsuitable for existing species. Sometimes a new species can be farmed on an existing site along side, or in polyculture with the species currently being farmed. There are possibly only about six sites left for finfish production using sea cages in Australia and none in Queensland for reef fish. Re-circulation is the future.

33. If you were to develop a new species, would you use the same strategy used to develop barramundi?

1. Yes. The strategy was available from overseas. Never reinvent the wheel.

2. Yes, but a much more rigorous and refined approach to develop a new species with less financial optimism. Selling a project on pioneering is very difficult because most companies want short-term profits but these things want longer term profits. Few companies invest on a 10-15 year outlook, mostly a 3-4 year outlook.

3. The organisation is doing the best possible with barramundi, working on disease, site development and strategic development in partnership with industry. Now it's done correctly but possibly not from go in the-mid 1980's, difficult to say even with hindsight. Strategic investing is in the right areas. Process needs re examination in 5 years.

4. Yes. Yes in the case of this project and apply the operational farming lessons.

5. Barramundi as a new species in Australia did not require initial marketing because of its name. A new species without same profile needs someone to develop the market.

6. Yes, use it as a model and modify it where it showed up weakness. Start small and expand with your market rather than getting ahead of it.

7. Yes.

Summary

New species strategy

Yes (5), Uncommitted (2).

The technology was available from overseas for transfer to Australia. Using the same strategy would work but with more rigour and less financial optimism. Many lessons from the barramundi experience are available for transfer to the development of a new species using barramundi as a model and modifying it where necessary. Barramundi as a new species in Australia did not require the initial marketing because of its name. A new species without same profile needs market development which should start small and expand with the market.

34. How important were governments in establishing the barramundi industry in Australia?

1. Important, especially in establishing the hatchery. A new species needs government support but after establishing hatcheries and the industry becomes viable government should exit.

2. Important, facilitating and identifying sites suitability and facilitating the path through the bureaucratic process to get the approvals and establishing an industry partnership for the hatchery. The government established it and the company contracted them to supply.

3. Critical. The Government did the initial technology transfer, took the risk and became involved in commercial development. An interested minister within government championing a species or the industry is very important to get things happening and resources made available.

4. Very important. Don't underestimate their support. The government is one reason why this project is here and not in Western Australia.

5. Very important. The Queensland Government has been supportive of the developing barramundi industry. The DPI was helpful in getting players together, exchanging ideas and formulating development plans for the industry. DPI wanted to see the industry develop from within, and not externally regulate and regulate where regulation is not wanted. Barramundi is already over regulated. Their role is to facilitate the developing itself. The Queensland Government has given more support than any other institution in Australia. The Government has pushed reef fish aquaculture in the last five years. There are some critical issues left out. One is site selection and the other is the ability to grow these species in whatever environment. The Great Barrier Reef is a huge limiting factor in any reef fish aquaculture development off Queensland. Aquaculture only succeeds where it has a developed network to help feed it and help support it. It may not work in isolation because of reliance on a service network and transport. The Northern Territory marine farm is yet to be proven. This is the agribusiness of aquaculture. Reef fish are exciting and the company would like involvement in the if breeding technology was more advanced. Money has gone into reef fish that could have further helped established industries. Industries are often at fault in relation to the assistance they don't make their needs known.

It's often difficult for individuals to champion their cause, try and get a business up and running and at the same trying to develop something new. When industries are slow to develop they need persistence and support from government for the long term. Aquaculture is never is a short-term thing.

6. There wasn't anything that couldn't be achieved with a number of farms and a good working relationship. Government and industry at different times are behind or ahead of each other. One overcomes a stumbling block then proceeds and vice versa. The DPI has a big role in information exchange. DPI helped this company with an ongoing disease problem. They worked out what it was but I don't know if the company would have worked it out just through practices or whether they had to be told what it was before a strategy could be put together to combat it. DPI can advance things quicker than if they weren't there.

7. They didn't do very much to help us. A few individuals at different times helped us greatly, but the governments themselves were more of a handicap than anything. They were too busy learning how they were going to control us rather than help us get going. They were too scared of what we were going to mean in workload for individuals in the government that what it could do for the community.

Summary

Importance of governments

Important (2), Critical (2), Very important (1), Uncommitted (2).

A new species needs government support and governments are vital at several stages of the process, firstly hatchery establishment and secondly site selection and approval, but after the industry is up and running, governments should exit leaving it to private enterprise. Government and industry can learn from each other.

Environment

35. When establishing, how did the barramundi industry cope with environmental issues?

1. On a State by State basis. The environment wasn't such a big issue in the North as in the South.

2. New industry working in a remote area, with promises of doing certain things over time. The company did a base line survey and will soon do an environmental management plan which is basically backwards. Doing it up front would be useless. As there is no major impact on the ecosystem here now, the company is sorting out the issues and discovering its impact then writing an environmental management plan that will govern future operations. The Great Barrier Reef Marine Park Authority would not accept that. *It's not really new species. It is new areas.* This is Australia's first big tropical operation. The Government was generous in its environmental constraints and giving us time to prove up our systems. The company will comply with all legislation,

3. They weren't really a huge factor. In the early days people weren't cross the environmental impacts at all. It's totally different today. The environmental issues are fundamentally important and there can never be enough information. Divers have zero visibility in a high risk environment site anchorage was assessed by throwing an anchor over and doing grabs. The cages dragged the moorings. Because it's a complex bottom composed of clays sandstone and mud requiring mud anchors. In hindsight it was not a proper assessment of the benthos. Environmental studies require much money.

5. Initially it wasn't too much of a problem, a few issues but not as many as marine aquaculture has because there are alternatives. The industry association has been reasonably proactive most of the time in trying to be well informed on environmental issues and impact by discussing options, farm design and potentially different farm plans to alleviate those impacts. Most people in the last five years have considered them in their farm development if they are new to the industry. Ten years ago it wasn't quite as critical, but for long term sustainability it's critical but freshwater is a limiting resource world wide. Re-use of freshwater in Australia is something most farmers can look towards, hydroponics, water re-cycling and this company is setting up an experiment to use effluent water on sugar cane. It has become more critical in the last five years which is associated with legislation and public opinion.

6. The earlier the establishment, the less restrictions. The environmental agencies walked around this site and said, "if you had to apply for it now you wouldn't get it." It wasn't the same issue then because there was no database to work with. Environmental issues have evolved. Eighteen years ago the first environmental impact study sitting in the back yard with a six pack of beer and an esky and a notebook. The study described the birds that flew over, the landscape, the soil structures, the water flows on the property. By the end off the six-pack it looked pretty good and was submitted as a four page hand written letter. The company's first Environmental Impact Statement. It went to the Water Quality Council as there was no Environmental Protection Authority. The Council issued a three page hand written letter and a discharge licence! The latest EIS was done externally, is over 700 pages and it cost $100,000's to complete. It has completely gone over the top. There has to be some rationale. Governments already know much about specific sites and more about sites than the player before he starts investigating. Governments should share their information, be up front and short circuit the process. For example the company's latest 700 page EIS. If another farmer on the same water system wanted to apply for a permit, the Government would have read 700 page report and known what that river could support to a certain extent. They should utilise that information before they make the next person write another 700 page report. It should be collaborative. It's a minefield and in Queensland alone there is about 280 million dollars of investment money which cannot be applied because of the red tape hurdles.

Summary

Environmental issues when establishing

The environment was not a big issue in the early days. The marine farm established with minimal environmental regulations. Instead the environmental manual is being written as the farm develops.

36. How would you now develop a new species taking into consideration contemporary environmental issues?

1. Species trans location may be an issue (indigenous or non-indigenous). Deal with the regulators and get appropriate approvals before investing too much. Politics is involved. The company has a flow through system, pumps brackish water into ponds feed the fish then put it back into the river. Nothing upstream and nothing downstream of us but must aim for a zero (pollution) discharge.

2. Environmental regulation does not play a big role in decision making. Site availability does and species to site does. Because of such limited site availability you have to work within the system and you know you can get out the other end.

3. If a new species takes pelletised feed in a pond, tank or cage the environmental controls are in place. If those controls did not prohibit company operations done in an environmentally sustainable framework, it would not impact. New species development is not environmentally constraining. In the long term environmental control is good.

4. Cobia must be able to handle an estuarine environment in the tropics with salinity fluctuations. They are a sub tropical and tropical fish, but typically are pelagic in their behaviour. The answer is in Asia because cobia is farmed in coastal environments.

5. Environmental issues are critical along with market assessment and species suitability for culture. Knowledge of the culture environment, how the species can be farmed and potential impact must be available at the start. It's often hard to quantify until the pilot project, but must be identified because it is part of the licensing process.

6. If attempting coral trout government assistance is needed on environmental and site. It took two years to complete an environmental study for an expansion of this site, going through all the relevant departments. The company would not attempt picking a site for coral trout then approaching all the departments individually. It would go to a government agency with the details including investment and ask for help getting approvals through. The marine farm went to the Northern Territory because that is where they received most help.

7. Don't know. *Every new species has a different range of problems.* With reef fish climatic conditions are important. Finfish aquaculture is very high production per hectare of water. The company stocks barramundi at 50 tonnes per hectare and reliably harvests those volumes. Doing barramundi at 50 tonnes/ha makes only a couple of dollars a kilo. But that means about $100,000/ha profit margin. That's what makes this barramundi operation competitive compared to the prawn farmers who are only doing 5-6 tonnes/ha and making $6-$8/kilo production, so they are getting $50,000-$60,000 per ha/ per crop. The barramundi take 18 months to grow to a large fish. In that period they are doing two crops which will give them similar returns per hectare to us. The opportunity with grouper finfish production overseas in Taiwan is they get similar tonnages per hectare, but the margins are probably $8-$10/kilo.

Summary

Establishing with contemporary environmental issues

Respondents all indicated that compliance with current regulations is essential but they would like more assistance from the government in the process.